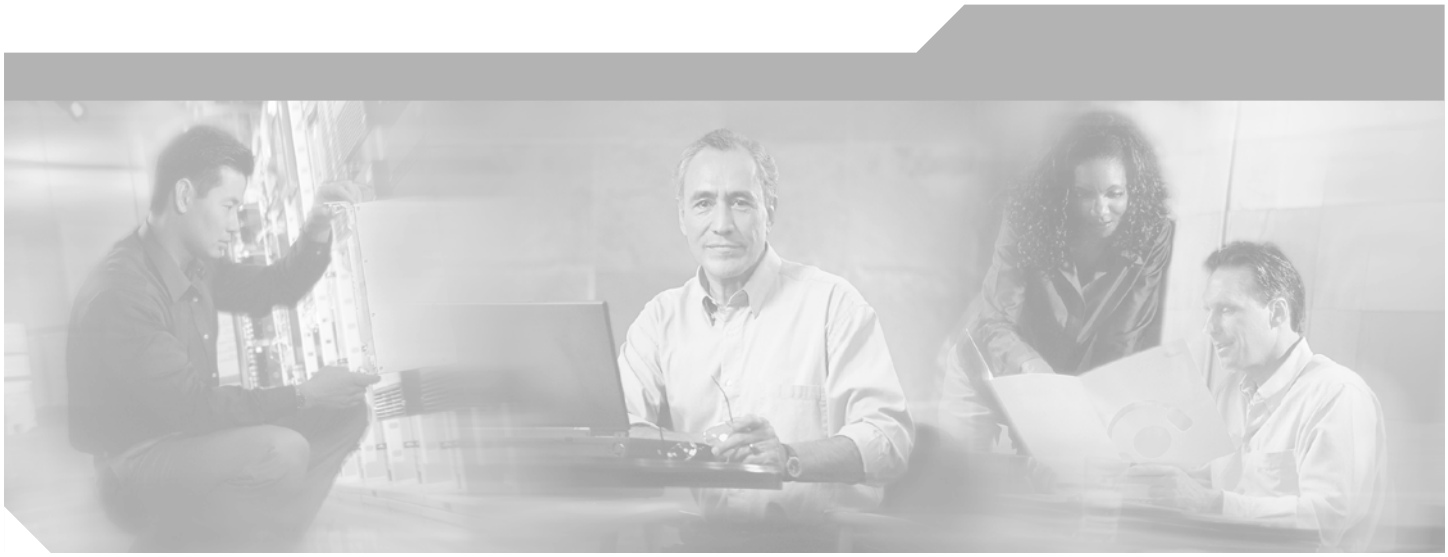

Catalyst 2950 and Catalyst 2955 Switch Software Configuration Guide

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Preface

Audience

The *Catalyst 2950 and Catalyst 2955 Switch Software Configuration Guide* is for the network manager responsible for configuring the Catalyst 2950 and the Catalyst 2955 switches, hereafter referred to as the *switches*. Before using this guide, you should be familiar with the concepts and terminology of Ethernet and local area networking.

Purpose

This guide provides information about configuring and troubleshooting a switch or switch clusters. It includes descriptions of the management interface options and the features supported by the switch software. The Catalyst 2950 switch is supported by either the standard software image (SI) or the enhanced software image (EI). The Catalyst 2955 switch is supported only by the EI.

The EI provides a richer set of features, including access control lists (ACLs), enhanced quality of service (QoS) features, extended-range VLANs, the IEEE 802.1W Rapid Spanning Tree Protocol (RSTP), and the IEEE 802.1S Multiple STP (MSTP), and Remote Switched Port Analyzer (RSPAN). For a list of switches that support the SI and the EI, see Table 1-1 in Chapter 1, "Overview."

Use this guide with other documents for information about these topics:

- Requirements—This guide assumes that you have met the hardware and software requirements and cluster compatibility requirements described in the release notes.
- Start-up information—This guide assumes that you have assigned switch IP information and passwords by using the setup program described in the release notes.
- Cluster Management Suite (CMS) information—This guide provides an overview of the CMS web-based, switch management interface. For information about CMS requirements and the procedures for browser and plug-in configuration and accessing CMS, refer to the release notes. For CMS field-level window descriptions and procedures, refer to the CMS online help.
- Cluster configuration—This guide provides information about planning for, creating, and maintaining switch clusters. Because configuring switch clusters is most easily performed through CMS, this guide does not provide the command-line interface (CLI) procedures. For the cluster commands, refer to the command reference for this release.
- CLI command information—This guide provides an overview for using the CLI. For complete syntax and usage information about the commands that have been specifically created or changed for the switches, refer to the command reference for this release.

This guide does not describe system messages you might encounter or how to install your switch. For more information, refer to the *Catalyst 2950 and Catalyst 2955 Desktop Switch System Message Guide* for this release, to the *Catalyst 2950 Desktop Switch Hardware Installation Guide*, and to the *Catalyst 2955 Switch Hardware Installation Guide*.

Note This guide does not repeat the concepts and CLI procedures provided in the standard Cisco IOS Release 12.1 documentation. For information about the standard IOS Release 12.1 commands, refer to the IOS documentation set available from the Cisco.com home page at **Service and Support > Technical Documents**. On the Cisco Product Documentation home page, select Release 12.1 from the Cisco IOS Software drop-down list.

Note This software release does not support the Catalyst 2950 LRE switches. For information about these switches, refer to the Catalyst 2950 LRE switch release notes.

Conventions

This guide uses these conventions to convey instructions and information:

Command descriptions use these conventions:

- Commands and keywords are in **boldface** text.
- Arguments for which you supply values are in *italic*.
- Square brackets ([ ]) indicate optional elements.
- Braces ({ }) group required choices, and vertical bars (|) separate the alternative elements.
- Braces and vertical bars within square brackets ([{ | }]) indicate a required choice within an optional element.

Interactive examples use these conventions:

- Terminal sessions and system displays are in `screen` font.
- Information you enter is in **`boldface screen`** font.
- Nonprinting characters, such as passwords or tabs, are in angle brackets (< >).

Notes, cautions, and tips use these conventions and symbols:

Note Means *reader take note*. Notes contain helpful suggestions or references to materials not contained in this manual.

Caution Means *reader be careful*. In this situation, you might do something that could result in equipment damage or loss of data.

Tip Means *the following will help you solve a problem*. The tips information might not be troubleshooting or even an action, but could be useful information.

Related Publications

These documents provide complete information about the switch and are available from this URL:

http://www.cisco.com/univercd/cc/td/doc/product/lan/cat2950/index.htm

You can order printed copies of documents with a DOC-xxxxxx= number from the Cisco.com sites and from the telephone numbers listed in the "Obtaining Documentation" section on page xxvi.

- *Release Notes for the Catalyst 2950 and Catalyst 2955 Switch* (not orderable but available on Cisco.com)

Note Switch requirements and procedures for initial configurations and software upgrades tend to change and therefore appear only in the release notes. Before installing, configuring, or upgrading the switch, refer to the release notes on Cisco.com for the latest information.

For hardware information for the Catalyst 2950 and Catalyst 2955 switches, refer to these documents:

- *Catalyst 2950 Desktop Switch Hardware Installation Guide* (order number DOC-7811157=)
- *Catalyst 2955 Hardware Installation Guide* (order number DOC-7814944=)

For software information about Release 12.1(13)EA1 or later for the Catalyst 2950 and Catalyst 2955 switches, refer to these documents:

- *Catalyst 2950 and Catalyst 2955 Desktop Switch Software Configuration Guide* (order number DOC-7811380=)
- *Catalyst 2950 and Catalyst 2955 Desktop Switch Command Reference* (order number DOC-7811381=)
- *Catalyst 2950 and Catalyst 2955 Desktop Switch System Message Guide* (order number DOC-7814233=)

For software information about Release 12.1(12c)EA1 for the Catalyst 2950 and Catalyst 2955 switches, refer to these documents:

- *Catalyst 2950 and Catalyst 2955 Switch Software Configuration Guide* (order number DOC-7815303=)
- *Catalyst 2950 and Catalyst 2955 Switch Command Reference* (order number DOC-7815304=)
- *Catalyst 2950 and Catalyst 2955 Switch System Message Guide* (order number DOC-7815306=)

Note The Catalyst 2955 switches are not supported by software releases earlier than Release 12.1(12c)EA1.

For information about the Catalyst 2950 LRE switches, refer to these documents:

- *Catalyst 2950 Desktop Switch Software Configuration Guide* (order number DOC-7814982=)
- *Catalyst 2950 Desktop Switch Command Reference* (order number DOC-7814984=)
- *Catalyst 2950 Desktop Switch System Message Guide (*order number DOC-7814981=)
- R*elease Notes for the Catalyst 2950 LRE Switch* (not orderable but available on Cisco.com)

For other information about related products, refer to these documents:

- *Catalyst GigaStack Gigabit Interface Converter Hardware Installation Guide* (order number DOC-786460=)
- Cluster Management Suite (CMS) online help (available only from the switch CMS software)
- *CWDM Passive Optical System Installation Note* (not orderable but is available on Cisco.com)
- *1000BASE-T Gigabit Interface Converter Installation Notes* (not orderable but is available on Cisco.com)

Obtaining Documentation

Cisco provides several ways to obtain documentation, technical assistance, and other technical resources. These sections explain how to obtain technical information from Cisco Systems.

World Wide Web

You can access the most current Cisco documentation on the World Wide Web at this URL:

http://www.cisco.com/univercd/home/home.htm

You can access the Cisco website at this URL:

http://www.cisco.com

International Cisco web sites can be accessed from this URL:

http://www.cisco.com/public/countries_languages.shtml

Documentation CD-ROM

Cisco documentation and additional literature are available in a Cisco Documentation CD-ROM package, which may have shipped with your product. The Documentation CD-ROM is updated monthly and may be more current than printed documentation. The CD-ROM package is available as a single unit or through an annual subscription.

Registered Cisco.com users can order the Documentation CD-ROM (product number DOC-CONDOCCD=) through the online Subscription Store:

http://www.cisco.com/go/subscription

Ordering Documentation

You can find instructions for ordering documentation at this URL:

http://www.cisco.com/univercd/cc/td/doc/es_inpck/pdi.htm

You can order Cisco documentation in these ways:

- Registered Cisco.com users (Cisco direct customers) can order Cisco product documentation from the Networking Products MarketPlace:

  http://www.cisco.com/en/US/partner/ordering/index.shtml

- Registered Cisco.com users can order the Documentation CD-ROM (Customer Order Number DOC-CONDOCCD=) through the online Subscription Store:

  http://www.cisco.com/go/subscription

- Nonregistered Cisco.com users can order documentation through a local account representative by calling Cisco Systems Corporate Headquarters (California, U.S.A.) at 408 526-7208 or, elsewhere in North America, by calling 800 553-NETS (6387).

Documentation Feedback

You can submit comments electronically on Cisco.com. On the Cisco Documentation home page, click **Feedback** at the top of the page.

You can e-mail your comments to bug-doc@cisco.com.

You can submit your comments by mail by using the response card behind the front cover of your document or by writing to the following address:

Cisco Systems
Attn: Customer Document Ordering
170 West Tasman Drive
San Jose, CA 95134-9883

We appreciate your comments.

Obtaining Technical Assistance

Cisco provides Cisco.com, which includes the Cisco Technical Assistance Center (TAC) Website, as a starting point for all technical assistance. Customers and partners can obtain online documentation, troubleshooting tips, and sample configurations from the Cisco TAC website. Cisco.com registered users have complete access to the technical support resources on the Cisco TAC website, including TAC tools and utilities.

Cisco.com

Cisco.com offers a suite of interactive, networked services that let you access Cisco information, networking solutions, services, programs, and resources at any time, from anywhere in the world.

Cisco.com provides a broad range of features and services to help you with these tasks:

- Streamline business processes and improve productivity
- Resolve technical issues with online support
- Download and test software packages
- Order Cisco learning materials and merchandise
- Register for online skill assessment, training, and certification programs

To obtain customized information and service, you can self-register on Cisco.com at this URL:

http://www.cisco.com

Technical Assistance Center

The Cisco TAC is available to all customers who need technical assistance with a Cisco product, technology, or solution. Two levels of support are available: the Cisco TAC website and the Cisco TAC Escalation Center. The avenue of support that you choose depends on the priority of the problem and the conditions stated in service contracts, when applicable.

We categorize Cisco TAC inquiries according to urgency:

- Priority level 4 (P4)—You need information or assistance concerning Cisco product capabilities, product installation, or basic product configuration.
- Priority level 3 (P3)—Your network performance is degraded. Network functionality is noticeably impaired, but most business operations continue.
- Priority level 2 (P2)—Your production network is severely degraded, affecting significant aspects of business operations. No workaround is available.
- Priority level 1 (P1)—Your production network is down, and a critical impact to business operations will occur if service is not restored quickly. No workaround is available.

Cisco TAC Website

You can use the Cisco TAC website to resolve P3 and P4 issues yourself, saving both cost and time. The site provides around-the-clock access to online tools, knowledge bases, and software. To access the Cisco TAC website, go to this URL:

http://www.cisco.com/tac

All customers, partners, and resellers who have a valid Cisco service contract have complete access to the technical support resources on the Cisco TAC website. Some services on the Cisco TAC website require a Cisco.com login ID and password. If you have a valid service contract but do not have a login ID or password, go to this URL to register:

http://tools.cisco.com/RPF/register/register.do

If you are a Cisco.com registered user, and you cannot resolve your technical issues by using the Cisco TAC website, you can open a case online at this URL:

http://www.cisco.com/en/US/support/index.html

If you have Internet access, we recommend that you open P3 and P4 cases through the Cisco TAC website so that you can describe the situation in your own words and attach any necessary files.

Cisco TAC Escalation Center

The Cisco TAC Escalation Center addresses priority level 1 or priority level 2 issues. These classifications are assigned when severe network degradation significantly impacts business operations. When you contact the TAC Escalation Center with a P1 or P2 problem, a Cisco TAC engineer automatically opens a case.

To obtain a directory of toll-free Cisco TAC telephone numbers for your country, go to this URL:

http://www.cisco.com/warp/public/687/Directory/DirTAC.shtml

Before calling, please check with your network operations center to determine the level of Cisco support services to which your company is entitled: for example, SMARTnet, SMARTnet Onsite, or Network Supported Accounts (NSA). When you call the center, please have available your service agreement number and your product serial number.

Obtaining Additional Publications and Information

Information about Cisco products, technologies, and network solutions is available from various online and printed sources.

- The *Cisco Product Catalog* describes the networking products offered by Cisco Systems as well as ordering and customer support services. Access the *Cisco Product Catalog* at this URL:

  http://www.cisco.com/en/US/products/products_catalog_links_launch.html

- Cisco Press publishes a wide range of networking publications. Cisco suggests these titles for new and experienced users: *Internetworking Terms and Acronyms Dictionary, Internetworking Technology Handbook, Internetworking Troubleshooting Guide,* and the *Internetworking Design Guide.* For current Cisco Press titles and other information, go to Cisco Press online at this URL:

  http://www.ciscopress.com

- *Packet* magazine is the Cisco monthly periodical that provides industry professionals with the latest information about the field of networking. You can access *Packet* magazine at this URL:

  http://www.cisco.com/en/US/about/ac123/ac114/about_cisco_packet_magazine.html

- *iQ Magazine* is the Cisco monthly periodical that provides business leaders and decision makers with the latest information about the networking industry. You can access *iQ Magazine* at this URL:

  http://business.cisco.com/prod/tree.taf%3fasset_id=44699&public_view=true&kbns=1.html

- *Internet Protocol Journal* is a quarterly journal published by Cisco Systems for engineering professionals involved in the design, development, and operation of public and private internets and intranets. You can access the *Internet Protocol Journal* at this URL:

  http://www.cisco.com/en/US/about/ac123/ac147/about_cisco_the_internet_protocol_journal.html

- Training—Cisco offers world-class networking training, with current offerings in network training listed at this URL:

  http://www.cisco.com/en/US/learning/le31/learning_recommended_training_list.html

Overview

This guide provides information about configuring and troubleshooting Catalyst 2950 and Catalyst 2955 switches.

The Catalyst 2955 switch supports all the features in the enhanced software image (EI) for the Catalyst 2950 switch (refer to the switch command reference for more details). The Catalyst 2955 switch also supports an additional set of features that are described in Chapter 3, "Configuring Catalyst 2955 Switch Alarms." The Catalyst 2955 switch has facilities to process alarms related to the temperature, power supply conditions, and status of the Ethernet ports.

This chapter provides these topics about the Catalyst 2950 and Catalyst 2955 switch software:

- Features, page 1-1
- Management Options, page 1-7
- Network Configuration Examples, page 1-8
- Where to Go Next, page 1-18

Features

The Catalyst 2950 and Catalyst 2955 software supports the switches listed in Table 1-1 and in the release notes.

Table 1-1 Switches Supported

Switch	Software Image
Catalyst 2950-12	SI[1]
Catalyst 2950-24	SI
Catalyst 2950C-24	EI
Catalyst 2950G-12-EI	EI
Catalyst 2950G-24-EI	EI
Catalyst 2950G-24-EI-DC	EI
Catalyst 2950G-48-EI	EI
Catalyst 2950SX-24	SI
Catalyst 2950T-24	EI
Catalyst 2955C-12	EI

Table 1-1 Switches Supported (continued)

Switch	Software Image
Catalyst 2955S-12	EI
Catalyst 2955T-12	EI

1. SI = standard software image

Note This software release does not support the Catalyst 2950 LRE switches. For information about these switches, refer to documentation for the Catalyst 2950 LRE switches.

This section describes the features supported in this release:

Note Some features require that you have the EI installed on your switch. For a list of the switches that support the EI, see Table 1-1, or refer to the release notes for this release.

Ease of Use and Ease of Deployment

- Cluster Management Suite (CMS) software for simplifying switch and switch cluster management through a web browser, such as Netscape Communicator or Microsoft Internet Explorer, from anywhere in your intranet
- Switch clustering technology used with CMS for
  - Unified configuration, monitoring, authentication, and software upgrade of multiple switches (refer to the release notes for a list of eligible cluster members).
  - Automatic discovery of candidate switches and creation of clusters of up to 16 switches that can be managed through a single IP address.
  - Extended discovery of cluster candidates that are not directly connected to the command switch.
- Hot Standby Router Protocol (HSRP) for command-switch redundancy. The redundant command switches used for HSRP must have compatible software releases.

Note See the "Advantages of Using CMS and Clustering Switches" section on page 1-8. Refer to the release notes for the CMS, cluster hardware, software, and browser requirements.

Performance

- Autosensing of speed on the 10/100 and 10/100/1000 ports and autonegotiation of duplex mode on the 10/100 ports for optimizing bandwidth
- IEEE 802.3X flow control on Gigabit Ethernet ports operating in full-duplex mode
- Fast EtherChannel and Gigabit EtherChannel for enhanced fault tolerance and for providing up to 2 Gbps of bandwidth between switches, routers, and servers
- Support for frames larger than 1500 bytes. The Catalyst 2950G-12-EI, 2950G-24-EI, 2950G-24-EI-DC, and 2950G-48-EI switches running Cisco IOS Release 12.1(6)EA2 or later support frame sizes from 1500 to 1530 bytes. The Catalyst 2955C-12, 2955S-12, and 2955T-12 switches running Release 12.1(12c)EA1 or later also support frame sizes from 1500 to 1530 bytes.

- Per-port broadcast storm control for preventing faulty end stations from degrading overall system performance with broadcast storms
- Port Aggregation Protocol (PAgP) and Link Aggregation Control Protocol (LACP) for automatic creation of EtherChannel links
- Internet Group Management Protocol (IGMP) snooping support to limit flooding of IP multicast traffic
- Multicast VLAN registration (MVR) to continuously send multicast streams in a multicast VLAN while isolating the streams from subscriber VLANs for bandwidth and security reasons
- IGMP filtering for controlling the set of multicast groups to which hosts on a switch port can belong
- Protected port (private VLAN edge port) option for restricting the forwarding of traffic to designated ports on the same switch
- Dynamic address learning for enhanced security

Manageability

- Cisco Intelligence Engine 2100 (IE2100) Series Cisco Networking Services (CNS) embedded agents for automating switch management, configuration storage and delivery (available only with the EI)
- Dynamic Host Configuration Protocol (DHCP)-based autoconfiguration for automatically configuring the switch during startup with IP address information and a configuration file that it receives during DHCP-based autoconfiguration

Note DHCP replaces the Bootstrap Protocol (BOOTP) feature autoconfiguration to ensure retrieval of configuration files by unicast TFTP messages. BOOTP is available in earlier software releases for this switch.

- Address Resolution Protocol (ARP) for identifying a switch through its IP address and its corresponding MAC address
- Cisco Discovery Protocol (CDP) versions 1 and 2 for network topology discovery and mapping between the switch and other Cisco devices on the network
- Network Time Protocol (NTP) for providing a consistent timestamp to all switches from an external source
- Directed unicast requests to a Trivial File Transfer Protocol (TFTP) server for obtaining software upgrades from a TFTP server
- Default configuration storage in Flash memory to ensure that the switch can be connected to a network and can forward traffic with minimal user intervention
- In-band management access through a CMS web-based session
- In-band management access through up to 16 simultaneous Telnet connections for multiple command-line interface (CLI)-based sessions over the network
- In-band management access through up to 5 simultaneous, encrypted Secure Shell (SSH) connections for multiple CLI-based sessions over the network (only available in the enhanced cryptographic software image)
- In-band management access through Simple Network Management Protocol (SNMP) versions 1, 2c, and 3 get and set requests
- Out-of-band management access through the switch console port to a directly-attached terminal or to a remote terminal through a serial connection and a modem

Note For additional descriptions of the management interfaces, see the "Management Options" section on page 1-7.

Redundancy

- HSRP for command-switch redundancy
- UniDirectional link detection (UDLD) on all Ethernet ports for detecting and disabling unidirectional links on fiber-optic interfaces caused by incorrect fiber-optic wiring or port faults
- IEEE 802.1D Spanning Tree Protocol (STP) for redundant backbone connections and loop-free networks. STP has these features:
  - Per-VLAN Spanning Tree (PVST) for balancing load across VLANs
  - Per-VLAN Rapid Spanning Tree (PVRST) for balancing load across VLANs (available only with the EI)
  - UplinkFast, cross-stack UplinkFast, and BackboneFast for fast convergence after a spanning-tree topology change and for achieving load balancing between redundant uplinks, including Gigabit uplinks and cross-stack Gigabit uplinks
- IEEE 802.1S Multiple STP (MSTP) for grouping VLANs into a spanning-tree instance, and providing for multiple forwarding paths for data traffic and load balancing (available only with the EI)
- IEEE 802.1W Rapid STP (RSTP) for rapid convergence of the spanning tree by immediately transitioning root and designated ports to the forwarding state (available only with the EI)
- Optional spanning-tree features available in the PVST, PVRST, and MSTP modes:
  - Port Fast for eliminating the forwarding delay by enabling a port to immediately transition from the blocking state to the forwarding state
  - BPDU guard for shutting down Port Fast-enabled ports that receive BPDUs
  - BPDU filtering for preventing a Port Fast-enabled port from sending or receiving BPDUs
  - Root guard for preventing switches outside the network core from becoming the spanning-tree root
  - Loop guard for preventing alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link

Note The switch supports up to 64 spanning-tree instances.

VLAN Support

- The switches support 250 port-based VLANs for assigning users to VLANs associated with appropriate network resources, traffic patterns, and bandwidth

Note The Catalyst 2950-12, Catalyst 2950-24, and Catalyst 2950SX-24 switches support only 64 port-based VLANs.

- The switch supports up to 4094 VLAN IDs to allow service provider networks to support the number of VLANs allowed by the IEEE 802.1Q standard (available only with the EI)

- IEEE 802.1Q trunking protocol on all ports for network moves, adds, and changes; management and control of broadcast and multicast traffic; and network security by establishing VLAN groups for high-security users and network resources
- VLAN Membership Policy Server (VMPS) for dynamic VLAN membership
- VLAN Trunking Protocol (VTP) pruning for reducing network traffic by restricting flooded traffic to links destined for stations receiving the traffic
- Dynamic Trunking Protocol (DTP) for negotiating trunking on a link between two devices and for negotiating the type of trunking encapsulation (802.1Q) to be used
- Voice VLAN for creating subnets for voice traffic from Cisco IP Phones

Security

- Bridge protocol data unit (BPDU) guard for shutting down a Port Fast-configured port when an invalid configuration occurs
- Protected port option for restricting the forwarding of traffic to designated ports on the same switch
- Password-protected access (read-only and read-write access) to management interfaces (CMS and CLI) for protection against unauthorized configuration changes
- Port security option for limiting and identifying MAC addresses of the stations allowed to access the port
- Port security aging to set the aging time for secure addresses on a port
- Multilevel security for a choice of security level, notification, and resulting actions
- MAC-based port-level security for restricting the use of a switch port to a specific group of source addresses and preventing switch access from unauthorized stations (available only with the EI)
- Terminal Access Controller Access Control System Plus (TACACS+), a proprietary feature for managing network security through a TACACS server
- IEEE 802.1X port-based authentication to prevent unauthorized devices from gaining access to the network
- IEEE 802.1X port-based authentication with VLAN assignment for restricting 802.1X-authenticated users to a specified VLAN (available only with the EI)
- IEEE 802.1X port-based authentication with port security for authenticating the port and managing network access for all MAC addresses, including that of the client (available only with the EI)
- IEEE 802.1X port-based authentication with port security for controlling access to 802.1X multiple-host ports
- IEEE 802.1X port-based authentication with voice VLAN to permit an IP phone access to the voice VLAN irrespective of the authorized or unauthorized state of the port
- Standard and extended IP access control lists (ACLs) for defining security policies (available only with the EI)

Quality of Service and Class of Service

- Automatic QoS (auto-QoS) to simplify the deployment of existing QoS features by classifying traffic and configuring egress queues (voice over IP only) (only available in the EI)
- Classification
  - IP Differentiated Services Code Point (IP DSCP) and class of service (CoS) marking priorities on a per-port basis for protecting the performance of mission-critical applications (only available with the EI)
  - Flow-based packet classification (classification based on information in the MAC, IP, and TCP/UDP headers) for high-performance quality of service at the network edge, allowing for differentiated service levels for different types of network traffic and for prioritizing mission-critical traffic in the network (only available in the EI)
  - Support for IEEE 802.1P CoS scheduling for classification and preferential treatment of high-priority voice traffic
  - Trusted boundary (detect the presence of a Cisco IP Phone, trust the CoS value received, and ensure port security. If the IP phone is not detected, disable the trusted setting on the port and prevent misuse of a high-priority queue.)
- Policing
  - Traffic-policing policies on the switch port for allocating the amount of the port bandwidth to a specific traffic flow
  - Policing traffic flows to restrict specific applications or traffic flows to metered, predefined rates
  - Up to 60 policers on ingress Gigabit-capable Ethernet ports
    Up to six policers on ingress 10/100 ports
    Granularity of 1 Mbps on 10/100 ports and 8 Mbps on 10/100/1000 ports
  - Out-of-profile markdown for packets that exceed bandwidth utilization limits

Note Policing is available only in the EI.

- Egress Policing and Scheduling of Egress Queues—Four egress queues on all switch ports. Support for strict priority and weighted round-robin (WRR) CoS policies

Monitoring

- Switch LEDs that provide visual port and switch status
- Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) for traffic monitoring on any port or VLAN

Note RSPAN is available only in the EI.

- SPAN support of Intrusion Detection Systems (IDSs) to monitor, repel, and report network security violations
- Four groups (history, statistics, alarms, and events) of embedded remote monitoring (RMON) agents for network monitoring and traffic analysis
- MAC address notification for tracking the MAC addresses that the switch has learned or removed

- Syslog facility for logging system messages about authentication or authorization errors, resource issues, and time-out events
- Layer 2 traceroute to identify the physical path that a packet takes from a source device to a destination device
- Facilities for processing alarms related to temperature, power-supply conditions, and the status of the Ethernet ports (available only on the Catalyst 2955 switch)

Management Options

The switches are designed for plug-and-play operation: you only need to assign basic IP information to the switch and connect it to the other devices in your network. If you have specific network needs, you can configure and monitor the switch—on an individual basis or as part of a switch cluster—through its various management interfaces.

This section discusses these topics:

- Management Interface Options, page 1-7
- Advantages of Using CMS and Clustering Switches, page 1-8

Management Interface Options

You can configure and monitor individual switches and switch clusters by using these interfaces:

- CMS—CMS is a graphical user interface that can be launched from anywhere in your network through a web browser such as Netscape Communicator or Microsoft Internet Explorer. CMS is already installed on the switch. Using CMS, you can configure and monitor a standalone switch, a specific cluster member, or an entire switch cluster. You can also display network topologies to gather link information and display switch images to modify switch and port level settings.

  For more information about CMS, see Chapter 4, “Getting Started with CMS.”
- CLI—The switch IOS CLI software is enhanced to support desktop-switching features. You can configure and monitor the switch and switch cluster members from the CLI. You can access the CLI either by connecting your management station directly to the switch console port or by using Telnet or SSH from a remote management station.

  For more information about the CLI, see Chapter 2, “Using the Command-Line Interface.”
- IE2100—Cisco Intelligence Engine 2100 Series Configuration Registrar is a network management device that works with embedded CNS Agents in the switch software. You can automate initial configurations and configuration updates by generating switch-specific configuration changes, sending them to the switch, executing the configuration change, and logging the results.

  For more information about IE2100, see Chapter 6, “Configuring IE2100 CNS Agents.”
- SNMP—SNMP provides a means to monitor and control the switch and switch cluster members. You can manage switch configuration settings, performance, and security and collect statistics by using SNMP management applications such as CiscoWorks2000 LAN Management Suite (LMS) and HP OpenView.

  You can manage the switch from an SNMP-compatible management station that is running platforms such as HP OpenView or SunNet Manager. The switch supports a comprehensive set of MIB extensions and four RMON groups.

  For more information about using SNMP, see the Chapter 25, “Configuring SNMP.”

Advantages of Using CMS and Clustering Switches

Using CMS and switch clusters can simplify and minimize your configuration and monitoring tasks. You can use Cisco switch clustering technology to manage up to 16 interconnected and supported Catalyst switches through one IP address as if they were a single entity. This can conserve IP addresses if you have a limited number of them. CMS is the easiest interface to use and makes switch and switch cluster management accessible to authorized users from any PC on your network.

By using switch clusters and CMS, you can:

- Manage and monitor interconnected Catalyst switches (refer to the release notes for a list of supported switches), regardless of their geographic proximity and interconnection media, including Ethernet, Fast Ethernet, Fast EtherChannel, Cisco GigaStack Gigabit Interface Converter (GBIC), Gigabit Ethernet, and Gigabit EtherChannel connections.
- Accomplish multiple configuration tasks from a single CMS window without needing to remember CLI commands to accomplish specific tasks.
- Apply actions from CMS to multiple ports and multiple switches at the same time to avoid re-entering the same commands for each individual port or switch. Here are some examples of globally setting and managing multiple ports and switches:
  - Port configuration such as speed and duplex settings
  - Port and console port security settings
  - NTP, STP, VLAN, and quality of service (QoS) configurations
  - Inventory and statistic reporting and link and switch-level monitoring and troubleshooting
  - Group software upgrades
- View a topology of interconnected devices to identify existing switch clusters and eligible switches that can join a cluster. You can also use the topology to quickly identify link information between switches.
- Monitor real-time status of a switch or multiple switches from the LEDs on the front-panel images. The system, redundant power system (RPS), and port LED colors on the images are similar to those on the physical LEDs.
- Use an interactive mode that takes you step-by-step through configuring complex features such as VLANs, ACLs, and QoS.
- Use a wizard that prompts you to provide the minimum required information to configure complex features such as QoS priorities for video traffic, priority levels for data applications, and security.

For more information about CMS, see Chapter 4, “Getting Started with CMS.” For more information about switch clusters, see Chapter 7, “Clustering Switches.”

Network Configuration Examples

This section provides network configuration concepts and includes examples of using the switch to create dedicated network segments and interconnecting the segments through Fast Ethernet and Gigabit Ethernet connections.

Note The examples in this section show the Catalyst 2950 switch but also apply to the Catalyst 2955 switch.

Design Concepts for Using the Switch

As your network users compete for network bandwidth, it takes longer to send and receive data. When you configure your network, consider the bandwidth required by your network users and the relative priority of the network applications they use.

Table 1-2 describes what can cause network performance to degrade and how you can configure your network to increase the bandwidth available to your network users.

Table 1-2 Increasing Network Performance

Network Demands	Suggested Design Methods
Too many users on a single network segment and a growing number of users accessing the Internet	• Create smaller network segments so that fewer users share the bandwidth, and use VLANs and IP subnets to place the network resources in the same logical network as the users who access those resources most. • Use full-duplex operation between the switch and its connected workstations.
• Increased power of new PCs, workstations, and servers • High demand from networked applications (such as e-mail with large attached files) and from bandwidth-intensive applications (such as multimedia)	• Connect global resources—such as servers and routers to which network users require equal access—directly to the Fast Ethernet or Gigabit Ethernet switch ports so that they have their own Fast Ethernet or Gigabit Ethernet segment. • Use the Fast EtherChannel or Gigabit EtherChannel feature between the switch and its connected servers and routers.

Bandwidth alone is not the only consideration when designing your network. As your network traffic profiles evolve, consider providing network services that can support applications such as voice and data integration and security.

Table 1-3 describes some network demands and how you can meet those demands.

Table 1-3 Providing Network Services

Network Demands	Suggested Design Methods
High demand for multimedia support	• Use IGMP and MVR to efficiently forward multicast traffic.
High demand for protecting mission-critical applications	• Use VLANs and protected ports to provide security and port isolation. • Use VLAN trunks, cross-stack UplinkFast, and BackboneFast for traffic-load balancing on the uplink ports so that the uplink port with a lower relative port cost is selected to carry the VLAN traffic.
An evolving demand for IP telephony	• Use QoS to prioritize applications such as IP telephony during congestion and to help control both delay and jitter within the network. • Use switches that support at least two queues per port to prioritize voice and data traffic as either high- or low-priority, based on 802.1P/Q.
A growing demand for using existing infrastructure to transport data and voice from a home or office to the Internet or an intranet at higher speeds	• Use the Catalyst 2900 LRE XL switches to provide up to 15 Mb of IP connectivity over existing infrastructure (existing telephone lines).

Figure 1-1 shows configuration examples of using the Catalyst switches to create these networks:

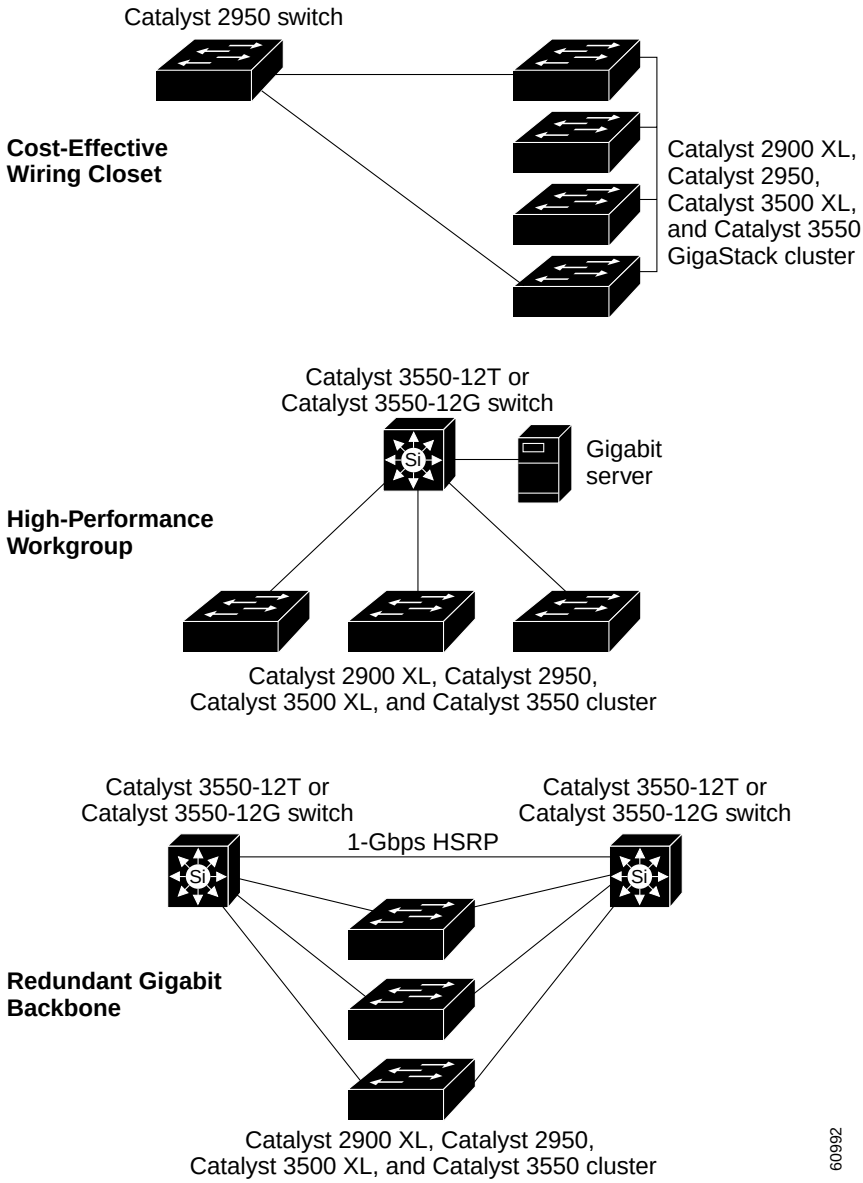
- Cost-effective wiring closet—A cost-effective way to connect many users to the wiring closet is to connect up to nine Catalyst 2900 XL, Catalyst 2950, Catalyst 3500 XL, and Catalyst 3550 switches through GigaStack GBIC connections. When you use a stack of Catalyst 2950G-48 switches, you can connect up to 432 users. To preserve switch connectivity if one switch in the stack fails, connect the bottom switch to the top switch to create a GigaStack loopback, and enable cross-stack UplinkFast on the cross-stack Gigabit uplinks.

  You can create backup paths by using Fast Ethernet, Gigabit, Fast EtherChannel, or Gigabit EtherChannel links. Using Gigabit modules on two of the switches, you can have redundant uplink connections to a Gigabit backbone switch such as the Catalyst 3550-12G switch. If one of the redundant connections fails, the other can serve as a backup path. You can configure the stack members and the Catalyst 3550-12G switch as a switch cluster to manage them through a single IP address.

- High-performance workgroup—For users who require high-speed access to network resources, use Gigabit modules to connect the switches directly to a backbone switch in a star configuration. Each switch in this configuration provides users with a dedicated 1-Gbps connection to network resources in the backbone. Compare this with the switches in a GigaStack configuration, where the 1-Gbps connection is shared among the switches. With the high speed uplink to the distribution server, the user can efficiently obtain and store data from servers. Using these Gigabit modules also provides flexibility in media and distance options:
  - 1000BASE-T GBIC: copper connections of up to 328 feet (100 meters)
  - 1000BASE-SX GBIC: fiber connections of up to 1804 feet (550 meters)
  - 1000BASE-LX/LH GBIC: fiber connections of up to 32,808 feet (10 kilometers)
  - 1000BASE-ZX GBIC: fiber connections of up to 328,084 feet (100 kilometers)
  - GigaStack GBIC module for creating a 1-Gbps stack configuration of up to nine supported switches. The GigaStack GBIC supports one full-duplex link (in a point-to-point configuration) or up to nine half-duplex links (in a stack configuration) to other Gigabit Ethernet devices. Using the required Cisco proprietary signaling and cabling, the GigaStack GBIC-to-GigaStack GBIC connection cannot exceed 3 feet (1 meter).

- Redundant Gigabit backbone—Using HSRP, you can create backup paths between Catalyst 3550-12T-L3 switches. To enhance network reliability and load balancing for different VLANs and subnets, you can connect the Catalyst 2950 switches, again in a star configuration, to two backbone switches. If one of the backbone switches fails, the second backbone switch preserves connectivity between the switches and network resources.

Figure 1-1 Example Configurations



Small to Medium-Sized Network Configuration

Figure 1-2 shows a configuration for a network that has up to 250 users. Users in this network require e-mail, file-sharing, database, and Internet access.

You optimize network performance by placing workstations on the same logical segment as the servers they access most often. This divides the network into smaller segments (or workgroups) and reduces the amount of traffic that travels over a network backbone, thereby increasing the bandwidth available to each user and improving server response time.

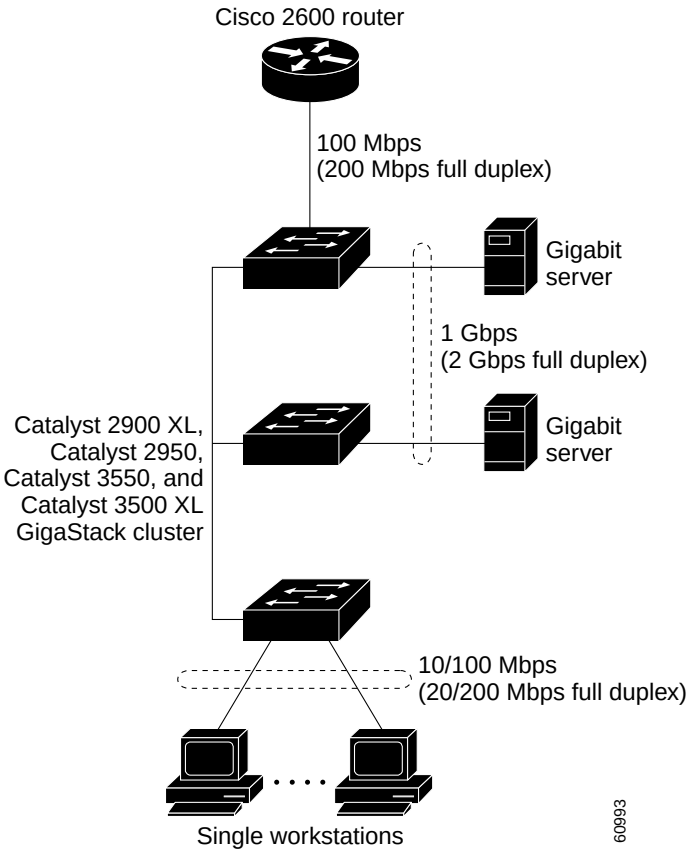
A *network backbone* is a high-bandwidth connection (such as Fast Ethernet or Gigabit Ethernet) that interconnects segments and network resources. It is required if numerous segments require access to the servers. The Catalyst 2900 XL, Catalyst 2950, Catalyst 3500 XL, and Catalyst 3550 switches in this network are connected through a GigaStack GBIC on each switch to form a 1-Gbps network backbone. This GigaStack can also be configured as a switch cluster, with primary and secondary command switches for redundant cluster management.

Workstations are connected directly to the 10/100 switch ports for their own 10- or 100-Mbps access to network resources (such as web and mail servers). When a workstation is configured for full-duplex operation, it receives up to 200 Mbps of dedicated bandwidth from the switch.

Servers are connected to the GBIC module ports on the switches, allowing 1-Gbps throughput to users when needed. When the switch and server ports are configured for full-duplex operation, the links provide 2 Gbps of bandwidth. For networks that do not require Gigabit performance from a server, connect the server to a Fast Ethernet or Fast EtherChannel switch port.

Connecting a router to a Fast Ethernet switch port provides multiple, simultaneous access to the Internet through one line.

Figure 1-2 Small to Medium-Sized Network Configuration



Collapsed Backbone and Switch Cluster Configuration

Figure 1-3 shows a configuration for a network of approximately 500 employees. This network uses a collapsed backbone and switch clusters. A collapsed backbone has high-bandwidth uplinks from all segments and subnetworks to a single device, such as a Gigabit switch, that serves as a single point for monitoring and controlling the network. You can use a Catalyst 3550-12T-L3 switch, as shown, or a Catalyst 3508G XL switch to create a Gigabit backbone. A Catalyst 3550-12T-L3 backbone switch provides the benefits of inter-VLAN routing and allows the router to focus on WAN access.

The workgroups are created by clustering all the Catalyst switches except the Catalyst 4908G-L3 switch. Using CMS and Cisco switch clustering technology, you can group the switches into multiple clusters, as shown, or into a single cluster. You can manage a cluster through the IP address of its active and standby command switches, regardless of the geographic location of the cluster members.

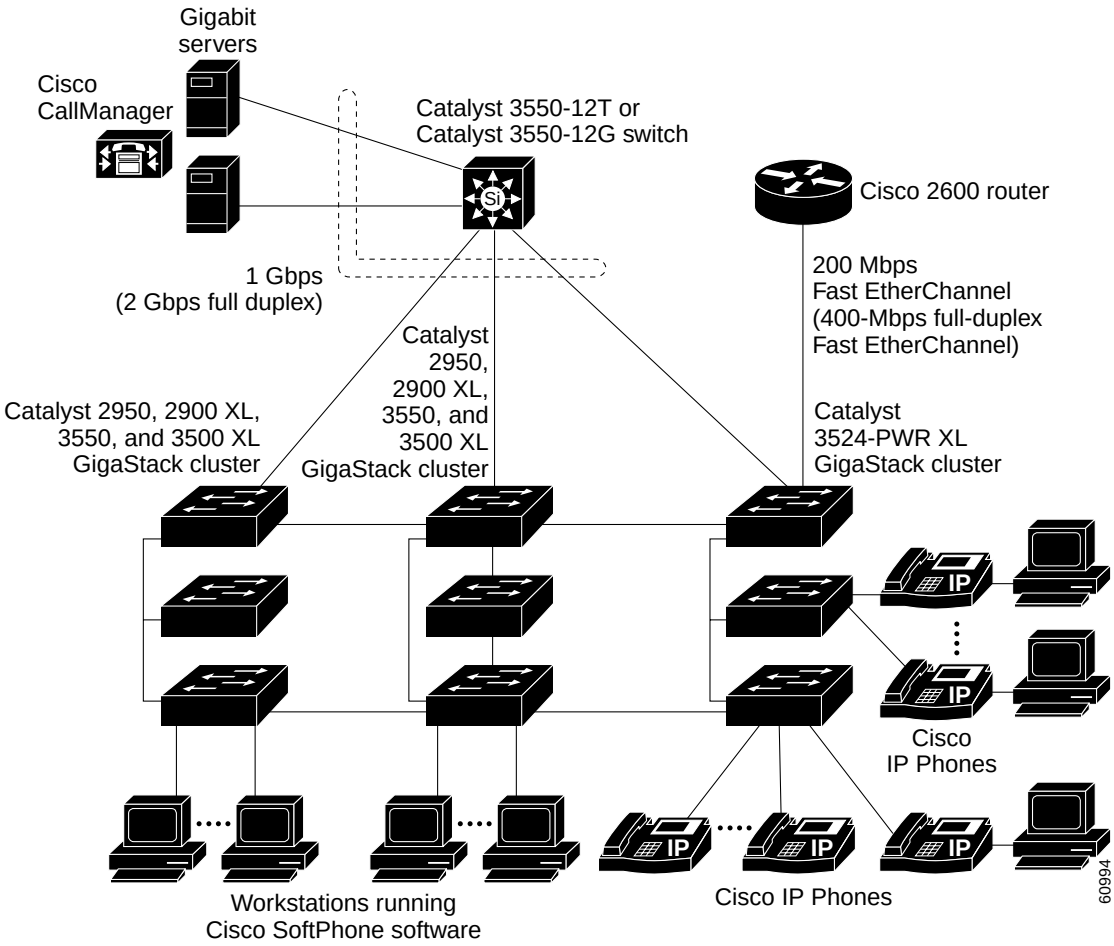
This network uses VLANs to segment the network logically into well-defined broadcast groups and for security management. Data and multimedia traffic are configured on the same VLAN. Voice traffic from the Cisco IP Phones are configured on separate voice VLAN IDs (VVIDs). You can have up to four VVIDs per wiring closet. If data, multimedia, and voice traffic are assigned to the same VLAN, only one VLAN can be configured per wiring closet. For any switch port connected to Cisco IP Phones, 802.1P/Q QoS gives forwarding priority to voice traffic over data traffic.

Grouping servers in a centralized location provides benefits such as security and easier maintenance. The Gigabit connections to a server farm provide the workgroups full access to the network resources (such as a call-processing server running Cisco CallManager software, a DHCP server, or an IP/TV multicast server).

Cisco IP Phones are connected—using standard straight-through, twisted-pair cable with RJ-45 connectors—to the 10/100 inline-power ports on the Catalyst 3524-PWR XL switches and to the 10/100 ports on the Catalyst 2950 switches. These multiservice switch ports automatically detect any IP phones that are connected. Cisco CallManager controls call processing, routing, and IP phone features and configuration. Users with workstations running Cisco SoftPhone software can place, receive, and control calls from their PCs. Using Cisco IP Phones, Cisco CallManager software, and Cisco SoftPhone software integrates telephony and IP networks, and the IP network supports both voice and data.

Each 10/100 inline-power port on the Catalyst 3524-PWR XL switches provides –48 VDC power to the Cisco IP Phone. The IP phone can receive redundant power when it is also connected to an AC power source. IP phones not connected to the Catalyst 3524-PWR XL switches receive power from an AC power source.

Figure 1-3 Collapsed Backbone and Switch Cluster Configuration


Gigabit servers
Cisco CallManager
Catalyst 3550-12T or Catalyst 3550-12G switch
Cisco 2600 router
1 Gbps (2 Gbps full duplex)
200 Mbps Fast EtherChannel (400-Mbps full-duplex Fast EtherChannel)
Catalyst 2950, 2900 XL, 3550, and 3500 XL GigaStack cluster
Catalyst 2950, 2900 XL, 3550, and 3500 XL GigaStack cluster
Catalyst 3524-PWR XL GigaStack cluster
IP
Cisco IP Phones
Workstations running Cisco SoftPhone software
Cisco IP Phones
60994

Large Campus Configuration

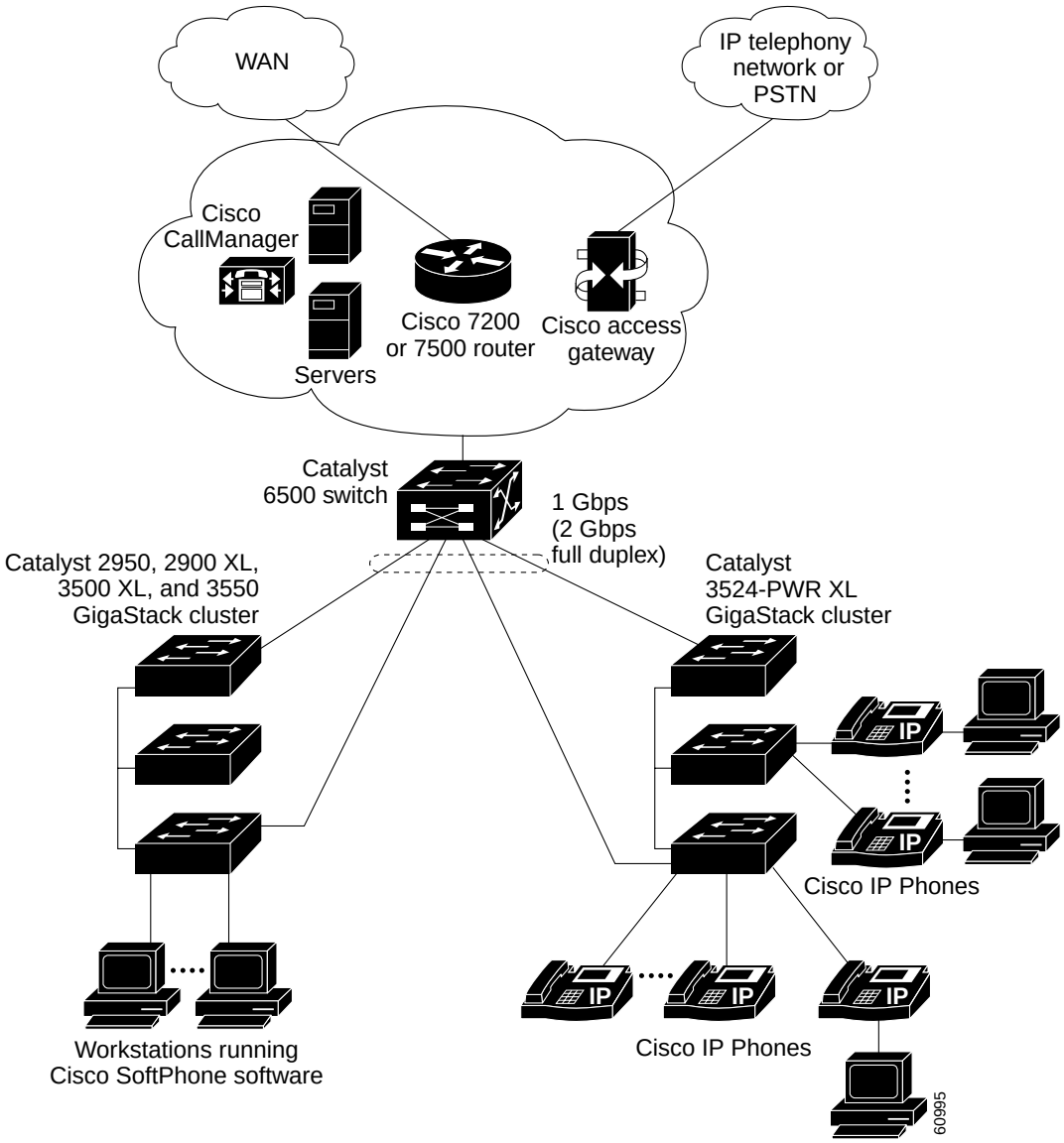
Figure 1-4 shows a configuration for a network of more than 1000 users. Because it can aggregate up to 130 Gigabit connections, a Catalyst 6500 multilayer switch is used as the backbone switch.

You can use the workgroup configurations shown in previous examples to create workgroups with Gigabit uplinks to the Catalyst 6500 switch. For example, you can use switch clusters that have a mix of Catalyst 2950 switches.

The Catalyst 6500 switch provides the workgroups with Gigabit access to core resources:

- Cisco 7000 series router for access to the WAN and the Internet.
- Server farm that includes a call-processing server running Cisco CallManager software. Cisco CallManager controls call processing, routing, and IP phone features and configuration.
- Cisco Access gateway (such as Cisco Access Digital Trunk Gateway or Cisco Access Analog Trunk Gateway) that connects the IP network to the Public Switched Telephone Network (PSTN) or to users in an IP telephony network.

Figure 1-4 Large Campus Configuration



Multidwelling Network Using Catalyst 2950 Switches

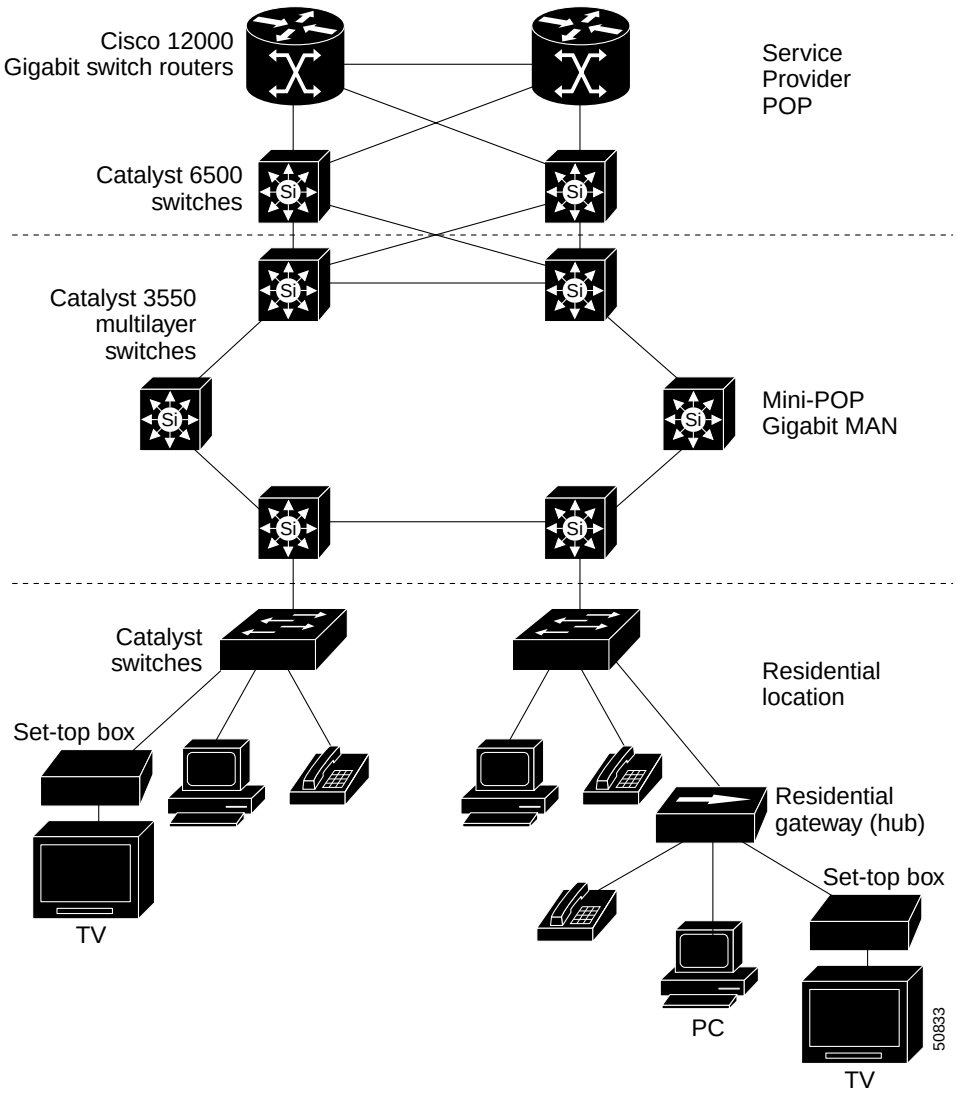
A growing segment of residential and commercial customers are requiring high-speed access to Ethernet metropolitan-area networks (MANs). Figure 1-5 shows a configuration for a Gigabit Ethernet MAN ring using Catalyst 3550 multilayer switches as aggregation switches in the mini-point-of-presence (POP) location. These switches are connected through 1000BASE-X GBIC ports.

The resident switches can be Catalyst 2950 switches, providing customers with high-speed connections to the MAN. Catalyst 2912-LRE or 2924-LRE XL Layer 2-only switches also can be used as residential switches for customers requiring connectivity through existing telephone lines. The Catalyst 2912-LRE or 2924-LRE XL switches can then connect to another residential switch or to an aggregation switch. For more information about the LRE switches, refer to the *Catalyst 2900 Series XL Hardware Installation Guide*.

All ports on the residential Catalyst 2950 switches (and Catalyst 2912-LRE XL or 2924-LRE XL switches if they are included) are configured as 802.1Q trunks with protected port and STP root guard features enabled. The protected port feature provides security and isolation between ports on the switch, ensuring that subscribers cannot view packets destined for other subscribers. STP root guard prevents unauthorized devices from becoming the STP root switch. All ports have IGMP snooping or CGMP enabled for multicast traffic management. ACLs on the uplink ports to the aggregating Catalyst 3550 multilayer switches provide security and bandwidth management.

The aggregating switches and routers provide services such as those described in the previous examples, "Small to Medium-Sized Network Configuration" and "Large Campus Configuration."

Figure 1-5 Catalyst 2950 Switches in a MAN Configuration



Long-Distance, High-Bandwidth Transport Configuration

Note To use the feature described in this section, you must have the EI installed on your switch.

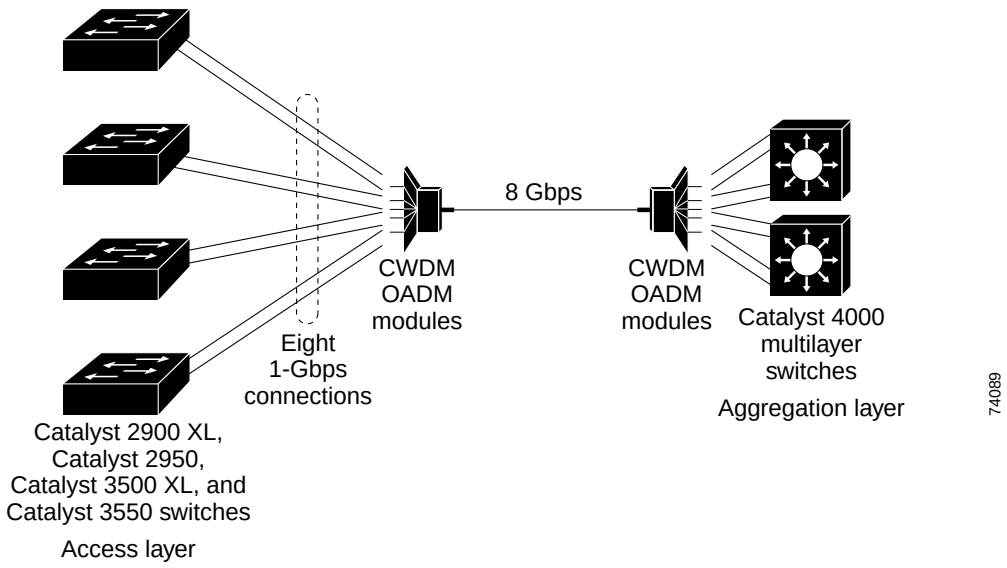
Figure 1-6 shows a configuration for transporting Gigabits of data from one location to an off-site backup facility over a single fiber-optic cable. The Catalyst switches have Coarse Wave Division Multiplexer (CWDM) fiber-optic GBIC modules installed. The CWDM GBIC modules can connect to distances of up to 393,701 feet (74.5 miles or 120 kilometers). Depending on the CWDM GBIC module, data is sent at wavelengths from 1470 to 1610 nanometers (nm). The higher the wavelength, the farther the transmission can travel. A common wavelength for long-distance transmissions is 1550 nm.

Up to eight CWDM GBIC modules, with any combination of wavelengths, can connect to a Cisco CWDM Passive Optical System. It combines (or multiplexes) the different CWDM wavelengths, allowing them to travel simultaneously on the same fiber-optic cable. The Cisco CWDM Passive Optical System on the receiving end separates (or demultiplexes) the different wavelengths.

Using CWDM technology with the switches translates to farther data transmission and an increased bandwidth capacity (up to 8 Gbps) on a single fiber-optic cable.

For more information about the CWDM GBIC modules and CWDM Passive Optical System, refer to the *CWDM Passive Optical System Installation Note*.

Figure 1-6 Long-Distance, High-Bandwidth Transport Configuration



Where to Go Next

Before configuring the switch, review these sections for start up information:

- Chapter 2, “Using the Command-Line Interface”
- Chapter 4, “Getting Started with CMS”
- Chapter 5, “Assigning the Switch IP Address and Default Gateway”
- Chapter 6, “Configuring IE2100 CNS Agents”

Using the Command-Line Interface

This chapter describes the IOS command-line interface (CLI) that you can use to configure your Catalyst 2950 and Catalyst 2955 switches. It contains these sections:

- IOS Command Modes, page 2-1
- Getting Help, page 2-3
- Abbreviating Commands, page 2-4
- Using no and default Forms of Commands, page 2-4
- Understanding CLI Messages, page 2-5
- Using Command History, page 2-5
- Using Editing Features, page 2-6
- Searching and Filtering Output of show and more Commands, page 2-9
- Accessing the CLI, page 2-9

IOS Command Modes

The Cisco IOS user interface is divided into many different modes. The commands available to you depend on which mode you are currently in. Enter a question mark (?) at the system prompt to obtain a list of commands available for each command mode.

When you start a session on the switch, you begin in user mode, often called user EXEC mode. Only a limited subset of the commands are available in user EXEC mode. For example, most of the user EXEC commands are one-time commands, such as **show** commands, which show the current configuration status, and **clear** commands, which clear counters or interfaces. The user EXEC commands are not saved when the switch reboots.

To have access to all commands, you must enter privileged EXEC mode. Normally, you must enter a password to enter privileged EXEC mode. From this mode, you can enter any privileged EXEC command or enter global configuration mode.

Using the configuration modes (global, interface, and line), you can make changes to the running configuration. If you save the configuration, these commands are stored and used when the switch reboots. To access the various configuration modes, you must start at global configuration mode. From global configuration mode, you can enter interface configuration mode and line configuration mode.

Table 2-1 describes the main command modes, how to access each one, the prompt you see in that mode, and how to exit the mode. The examples in the table use the host name *Switch*.

Table 2-1 Command Mode Summary

Mode	Access Method	Prompt	Exit Method	About This Mode
User EXEC	Begin a session with your switch.	`Switch>`	Enter **logout** or **quit**.	Use this mode to • Change terminal settings. • Perform basic tests. • Display system information.
Privileged EXEC	While in user EXEC mode, enter the **enable** command.	`Switch#`	Enter **disable** to exit.	Use this mode to verify commands that you have entered. Use a password to protect access to this mode.
Global configuration	While in privileged EXEC mode, enter the **configure** command.	`Switch(config)#`	To exit to privileged EXEC mode, enter **exit** or **end**, or press **Ctrl-Z**.	Use this mode to configure parameters that apply to the entire switch.
Config-vlan	While in global configuration mode, enter the **vlan** *vlan-id* command.	`Switch(config-vlan)#`	To exit to global configuration mode, enter the **exit** command. To return to privileged EXEC mode, press **Ctrl-Z** or enter **end**.	Use this mode to configure VLAN parameters. When VTP mode is transparent, you can create extended-range VLANs (VLAN IDs greater than 1005) and save configurations in the switch startup configuration file.
VLAN configuration	While in privileged EXEC mode, enter the **vlan database** command.	`Switch(vlan)#`	To exit to privileged EXEC mode, enter **exit**.	Use this mode to configure VLAN parameters for VLANs 1 to 1005 in the VLAN database.

Table 2-1 Command Mode Summary (continued)

Mode	Access Method	Prompt	Exit Method	About This Mode
Interface configuration	While in global configuration mode, enter the **interface** command (with a specific interface).	`Switch(config-if)#`	To exit to global configuration mode, enter **exit**. To return to privileged EXEC mode, press **Ctrl-Z** or enter **end**.	Use this mode to configure parameters for the Ethernet interfaces. To configure multiple interfaces with the same parameters, see the "Configuring a Range of Interfaces" section on page 11-6.
Line configuration	While in global configuration mode, specify a line with the **line vty** or **line console** command.	`Switch(config-line)#`	To exit to global configuration mode, enter **exit**. To return to privileged EXEC mode, press **Ctrl-Z** or enter **end**.	Use this mode to configure parameters for the terminal line.

Getting Help

You can enter a question mark (?) at the system prompt to display a list of commands available for each command mode. You can also obtain a list of associated keywords and arguments for any command, as shown in Table 2-2.

Table 2-2 Help Summary

Command	Purpose
help	Obtain a brief description of the help system in any command mode.

*abbreviated-command-entry***?**	Obtain a list of commands that begin with a particular character string.
	For example:
	`Switch# di?`
	`dir  disable  disconnect`

abbreviated-command-entry<**Tab**>	Complete a partial command name.
	For example:
	`Switch# sh conf<tab>`
	`Switch# show configuration`

?	List all commands available for a particular command mode. For example: `Switch> ?`

Table 2-2 Help Summary (continued)

Command	Purpose
command **?**	List the associated keywords for a command. For example: `Switch> show ?`

command keyword **?**	List the associated arguments for a keyword.
	For example:
	`Switch(config)# cdp holdtime ?`
	`  <10-255>  Length of time (in sec) that receiver must keep this packet`

Abbreviating Commands

You have to enter only enough characters for the switch to recognize the command as unique. This example shows how to enter the **show configuration** privileged EXEC command:

```
Switch# show conf
```

Using no and default Forms of Commands

Almost every configuration command also has a **no** form. In general, use the **no** form to disable a feature or function or reverse the action of a command. For example, the **no shutdown** interface configuration command reverses the shutdown of an interface. Use the command without the keyword **no** to re-enable a disabled feature or to enable a feature that is disabled by default.

Configuration commands can also have a **default** form. The **default** form of a command returns the command setting to its default. Most commands are disabled by default, so the **default** form is the same as the **no** form. However, some commands are enabled by default and have variables set to certain default values. In these cases, the **default** command enables the command and sets variables to their default values.

Understanding CLI Messages

Table 2-3 lists some error messages that you might encounter while using the CLI to configure your switch.

Table 2-3 Common CLI Error Messages

Error Message	Meaning	How to Get Help
`% Ambiguous command: "show con"`	You did not enter enough characters for your switch to recognize the command.	Re-enter the command followed by a question mark (?) with a space between the command and the question mark. The possible keywords that you can enter with the command are displayed.
`% Incomplete command.`	You did not enter all the keywords or values required by this command.	Re-enter the command followed by a question mark (?) with a space between the command and the question mark. The possible keywords that you can enter with the command are displayed.
`% Invalid input detected at '^' marker.`	You entered the command incorrectly. The caret (^) marks the point of the error.	Enter a question mark (?) to display all the commands that are available in this command mode. The possible keywords that you can enter with the command are displayed.

Using Command History

The IOS provides a history or record of commands that you have entered. This feature is particularly useful for recalling long or complex commands or entries, including access lists. You can customize the command history feature to suit your needs as described in these sections:

- Changing the Command History Buffer Size, page 2-5
- Recalling Commands, page 2-6
- Disabling the Command History Feature, page 2-6

Changing the Command History Buffer Size

By default, the switch records ten command lines in its history buffer. Beginning in privileged EXEC mode, enter this command to change the number of command lines that the switch records during the current terminal session:

```
Switch# terminal history [size number-of-lines]
```

The range is from 0 to 256.

Beginning in line configuration mode, enter this command to configure the number of command lines the switch records for all sessions on a particular line:

```
Switch(config-line)# history [size number-of-lines]
```

The range is from 0 to 256.

Recalling Commands

To recall commands from the history buffer, perform one of the actions listed in Table 2-4:

Table 2-4 Recalling Commands

Action[1]	Result
Press **Ctrl-P** or the up arrow key.	Recall commands in the history buffer, beginning with the most recent command. Repeat the key sequence to recall successively older commands.
Press **Ctrl-N** or the down arrow key.	Return to more recent commands in the history buffer after recalling commands with **Ctrl-P** or the up arrow key. Repeat the key sequence to recall successively more recent commands.
show history	While in privileged EXEC mode, list the last several commands that you just entered. The number of commands that are displayed is determined by the setting of the **terminal history** global configuration command and **history** line configuration command.

1. The arrow keys function only on ANSI-compatible terminals such as VT100s.

Disabling the Command History Feature

The command history feature is automatically enabled.

To disable the feature during the current terminal session, enter the **terminal no history** privileged EXEC command.

To disable command history for the line, enter the **no history** line configuration command.

Using Editing Features

This section describes the editing features that can help you manipulate the command line. It contains these sections:

- Enabling and Disabling Editing Features, page 2-7
- Editing Commands through Keystrokes, page 2-7
- Editing Command Lines that Wrap, page 2-8

Enabling and Disabling Editing Features

Although enhanced editing mode is automatically enabled, you can disable it.

To re-enable the enhanced editing mode for the current terminal session, enter this command in privileged EXEC mode:

```
Switch# terminal editing
```

To reconfigure a specific line to have enhanced editing mode, enter this command in line configuration mode:

```
Switch(config-line)# editing
```

To globally disable enhanced editing mode, enter this command in line configuration mode:

```
Switch(config-line)# no editing
```

Editing Commands through Keystrokes

Table 2-5 shows the keystrokes that you need to edit command lines.

Table 2-5 Editing Commands through Keystrokes

Capability	Keystroke[1]	Purpose
Move around the command line to make changes or corrections.	Press **Ctrl-B**, or press the left arrow key.	Move the cursor back one character.
	Press **Ctrl-F**, or press the right arrow key.	Move the cursor forward one character.
	Press **Ctrl-A**.	Move the cursor to the beginning of the command line.
	Press **Ctrl-E**.	Move the cursor to the end of the command line.
	Press **Esc B**.	Move the cursor back one word.
	Press **Esc F**.	Move the cursor forward one word.
	Press **Ctrl-T**.	Transpose the character to the left of the cursor with the character located at the cursor.
Recall commands from the buffer and paste them in the command line. The switch provides a buffer with the last ten items that you deleted.	Press **Ctrl-Y**.	Recall the most recent entry in the buffer.
	Press **Esc Y**.	Recall the next buffer entry. The buffer contains only the last 10 items that you have deleted or cut. If you press **Esc Y** more than ten times, you cycle to the first buffer entry.
Delete entries if you make a mistake or change your mind.	Press the **Delete** or **Backspace** key.	Erase the character to the left of the cursor.

Table 2-5 Editing Commands through Keystrokes (continued)

Capability	Keystroke[1]	Purpose
	Press **Ctrl-D**.	Delete the character at the cursor.
	Press **Ctrl-K**.	Delete all characters from the cursor to the end of the command line.
	Press **Ctrl-U** or **Ctrl-X**.	Delete all characters from the cursor to the beginning of the command line.
	Press **Ctrl-W**.	Delete the word to the left of the cursor.
	Press **Esc D**.	Delete from the cursor to the end of the word.
Capitalize or lowercase words or capitalize a set of letters.	Press **Esc C**.	Capitalize at the cursor.
	Press **Esc L**.	Change the word at the cursor to lowercase.
	Press **Esc U**.	Capitalize letters from the cursor to the end of the word.
Designate a particular keystroke as an executable command, perhaps as a shortcut.	Press **Ctrl-V** or **Esc Q**.	
Scroll down a line or screen on displays that are longer than the terminal screen can display. **Note** The More prompt is used for any output that has more lines than can be displayed on the terminal screen, including **show** command output. You can use the **Return** and **Space** bar keystrokes whenever you see the More prompt.	Press the **Return** key.	Scroll down one line.
	Press the **Space** bar.	Scroll down one screen.
Redisplay the current command line if the switch suddenly sends a message to your screen.	Press **Ctrl-L** or **Ctrl-R**.	Redisplay the current command line.

1. The arrow keys function only on ANSI-compatible terminals such as VT100s.

Editing Command Lines that Wrap

You can use a wraparound feature for commands that extend beyond a single line on the screen. When the cursor reaches the right margin, the command line shifts ten spaces to the left. You cannot see the first ten characters of the line, but you can scroll back and check the syntax at the beginning of the command.

To scroll back to the beginning of the command entry, press **Ctrl-B** or the left arrow key repeatedly. You can also press **Ctrl-A** to immediately move to the beginning of the line.

Note The arrow keys function only on ANSI-compatible terminals such as VT100s.

In this example, the **access-list** global configuration command entry extends beyond one line. When the cursor first reaches the end of the line, the line is shifted ten spaces to the left and redisplayed. The dollar sign ($) shows that the line has been scrolled to the left. Each time the cursor reaches the end of the line, the line is again shifted ten spaces to the left.

```
Switch(config)# access-list 101 permit tcp 131.108.2.5 255.255.255.0 131.108.1
Switch(config)# $ 101 permit tcp 131.108.2.5 255.255.255.0 131.108.1.20 255.25
Switch(config)# $t tcp 131.108.2.5 255.255.255.0 131.108.1.20 255.255.255.0 eq
Switch(config)# $108.2.5 255.255.255.0 131.108.1.20 255.255.255.0 eq 45
```

After you complete the entry, press **Ctrl-A** to check the complete syntax before pressing the **Return** key to execute the command. The dollar sign ($) appears at the end of the line to show that the line has been scrolled to the right:

```
Switch(config)# access-list 101 permit tcp 131.108.2.5 255.255.255.0 131.108.1$
```

The software assumes you have a terminal screen that is 80 columns wide. If you have a width other than that, use the **terminal width** privileged EXEC command to set the width of your terminal.

Use line wrapping with the command history feature to recall and modify previous complex command entries. For information about recalling previous command entries, see the "Editing Commands through Keystrokes" section on page 2-7.

Searching and Filtering Output of show and more Commands

You can search and filter the output for **show** and **more** commands. This is useful when you need to sort through large amounts of output or if you want to exclude output that you do not need to see.

To use this functionality, enter a **show** or **more** command followed by the *pipe* character (|), one of the keywords **begin**, **include**, or **exclude**, and an expression that you want to search for or filter out:

command **|** {**begin** | **include** | **exclude**} *regular-expression*

Expressions are case sensitive. For example, if you enter **| exclude output**, the lines that contain *output* are not displayed, but the lines that contain *Output* are displayed.

This example shows how to include in the output display only lines where the expression *protocol* appears:

```
Switch# show interfaces | include protocol
Vlan1 is up, line protocol is up
Vlan10 is up, line protocol is down
GigabitEthernet0/1 is up, line protocol is down
GigabitEthernet0/2 is up, line protocol is up
```

Accessing the CLI

Before you can access the CLI, you need to connect a terminal or PC to the switch console port and power on the switch as described in the hardware installation guide that shipped with your switch. Then, to understand the boot process and the options available for assigning IP information, see Chapter 5, "Assigning the Switch IP Address and Default Gateway."

If your switch is already configured, you can access the CLI through a local console connection or through a remote Telnet session, but your switch must first be configured for this type of access. For more information, see the "Setting a Telnet Password for a Terminal Line" section on page 9-5.

You can establish a connection with the switch by either

- Connecting the switch console port to a management station or dial-up modem. For information about connecting to the console port, refer to the switch hardware installation guide.
- Using any Telnet TCP/IPor encrypted Secure Shell (SSH) package from a remote management station. The switch must have network connectivity with the Telnet or SSH client, and the switch must have an enable secret password configured.

  For information about configuring the switch for Telnet access, see the "Setting a Telnet Password for a Terminal Line" section on page 9-5. The switch supports up to 16 simultaneous Telnet sessions. Changes made by one Telnet user are reflected in all other Telnet sessions.

  For information about configuring the switch for SSH, see the "Configuring the Switch for Secure Shell" section on page 9-31. The switch supports up to five simultaneous secure SSH sessions.

After you connect through the console port, through a Telnet session, or through an SSH session, the user EXEC prompt appears on the management station.

Accessing the CLI from a Browser

This procedure assumes you have met the software requirements (including browser and Java plug-in configurations) and have assigned IP information and a Telnet password to the switch or command switch, as described in the release notes.

To access the CLI from a web browser, follow these steps:

Step 1 Start one of the supported browsers.

Step 2 In the **URL** field, enter the IP address of the command switch.

Step 3 When the Cisco Systems Access page appears, click **Telnet** to start a Telnet session.

You can also access the CLI by clicking **Monitor the router- HTML access to the command line interface** from the Cisco Systems Access page. For information about the Cisco Systems Access page, see the "Accessing CMS" section in the release notes.

Step 4 Enter the switch password.

The user EXEC prompt appears on the management station.

Note Copies of the CMS pages that you display are saved in your browser memory cache until you exit the browser session. A password is not required to redisplay these pages, including the Cisco Systems Access page. You can access the CLI by clicking **Web Console - HTML access to the command line interface** from a cached copy of the Cisco Systems Access page. To prevent unauthorized access to CMS and the CLI, exit your browser to end the browser session.

Configuring Catalyst 2955 Switch Alarms

This section describes how to configure the different alarms for the Catalyst 2955 switch.

Note The alarms described in this chapter are not available on the Catalyst 2950 switch.

For complete syntax and usage information for the commands used in this chapter, refer to the switch command reference for this release.

This chapter consists of these sections:

- Understanding Catalyst 2955 Switch Alarms, page 3-1
- Configuring Catalyst 2955 Switch Alarms, page 3-4
- Displaying Catalyst 2955 Switch Alarms Status, page 3-12

Understanding Catalyst 2955 Switch Alarms

The Catalyst 2955 switch software monitors switch conditions on a per port or a switch basis. If the conditions present on the switch or port do not match the parameters set by the user, the switch software triggers an alarm or a system message. By default, the switch software sends the system messages to a system message logging facility, or a *syslog* facility. You can also configure the switch to send Simple Network Management Protocol (SNMP) traps to an SNMP server. You can configure the switch to trigger an external alarm device by using the two independent alarm relays (major or minor). For more information on how to configure the alarms, see the "Configuring Catalyst 2955 Switch Alarms" section on page 3-4.

This section includes information about these topics:

- Global Status Monitoring Alarms, page 3-2
- FCS Error Hysteresis Threshold, page 3-2
- Port Status Monitoring Alarms, page 3-3
- Triggering Alarm Options, page 3-4

Global Status Monitoring Alarms

The Catalyst 2955 switch contains facilities for processing alarms related to temperature and power supply conditions. These are referred to as global or facility alarms. Table 3-1 lists the three global alarms and their descriptions and functions.

Table 3-1 Catalyst 2955 Global Status Monitoring Alarms

Alarm	Description
Power Supply Alarm	The Catalyst 2955 switch monitors dual DC power supply levels. If the system is configured to operate in a dual power mode, an alarm triggers if a power supply fails or is missing. The alarm is automatically cleared when both power supplies are present or working. You can configure the power supply alarm to be connected to the hardware relays. For more information, see the "Configuring the Power Supply Alarm" section on page 3-5.
Temperature Alarms	The Catalyst 2955 switch contains a temperature sensor that monitors the environmental conditions inside the switch. The switch contains two alarms that are associated with temperature. • The primary alarm is enabled automatically to trigger both at a low temperature (-20°C) and a high temperature (95°C) for the safe operation of the switch. It cannot be changed or disabled. By default, the primary temperature alarm is associated with the major relay. • You can use the secondary temperature alarm to trigger an alarm when the system temperature is greater than the configured temperature threshold. The lower threshold is configurable within the range of 40°C to the maximum threshold, 95°C. The secondary alarm is disabled by default. For more information, see the "Configuring the Switch Temperature Alarms" section on page 3-6.

FCS Error Hysteresis Threshold

The Ethernet standard calls for a maximum bit error rate of 10^{-8}. In the Catalyst 2955 switch, the bit error rate configurable range is from 10^{-6} to 10^{-11}. The bit error rate input to the switch is a positive exponent. If you want to configure the bit error rate of 10^{-9}, then you enter the value 9 for the exponent. By default, the FCS bit error rate is 10^{-8}.

You can set the FCS error hysteresis threshold to prevent the toggle of the alarm when the actual bit error rate fluctuates near the configured bit error rate. The hysteresis threshold is defined as the ratio between the alarm clear threshold to the alarm set threshold, expressed as a percentage value.

For example, if the FCS bit error rate alarm value is configured to 10^{-8}, that value is the alarm set threshold. To set the alarm clear threshold at $5*10^{-10}$, the hysteresis, value *h*, is determined as follows:

h = alarm clear threshold / alarm set threshold

$h = 5*10^{-10} / 10^{-8} = 5*10^{-2} = 0.05 = 5$ percent

The FCS hysteresis threshold is applied to all ports on the Catalyst 2955 switch. The allowable range is from 1 to 10 percent. The default value is 10 percent. See the "Configuring the FCS Bit Error Rate Alarm" section on page 3-8 for more information.

Port Status Monitoring Alarms

The Catalyst 2955 switch can also monitor the status of the Ethernet ports and generate alarm messages based on the alarms listed in Table 3-2. To save user time and effort, the switch supports changing alarm configurations by using alarm profiles. You can create a number of profiles and assign one of these profiles to each Ethernet port.

Alarm profiles provide a mechanism for you to enable or disable alarm conditions for a port and associate the alarm conditions with one or both alarm relays. You can also use alarm profiles to set alarm conditions to send alarm traps to an SNMP server and system messages to a syslog server. The alarm profile *defaultPort* is applied to all interfaces in the factory configuration (by default).

Note You can associate multiple alarms to one relay or one alarm to both relays.

Table 3-2 lists the port status monitoring alarms and their descriptions and functions. Each fault condition is assigned a severity level based on the Cisco IOS System Error Message Severity Level.

Table 3-2 Catalyst 2955 Port Status Monitoring Alarms

Alarm	Description
Link Fault alarm	The Catalyst 2955 switch generates a link fault alarm when there are problems with a port physical layer that cause unreliable data transmission. A typical link fault condition is loss of signal or clock. The link fault alarm is cleared automatically when the link fault condition is cleared. The severity for this alarm is *error condition*, level 3.
Port not Forwarding alarm	The switch generates a port not forwarding alarm when a port is not forwarding packets. This alarm is cleared automatically when the port begins to forward packets. The severity for this alarm is *warning*, level 4.
Port is not Operating alarm	The switch generates a port is not operating alarm when it finds that a port is in a failed state during the startup self-test. When triggered, the port is not operating alarm is only cleared when the switch is restarted and the port is found to be operational. The severity for this alarm is *error condition*, level 3.
FCS Bit Error Rate alarm	The switch generates an FCS Bit Error Rate alarm when the actual FCS Bit Error Rate is close to the configured FCS Bit Error Rate. You can set the FCS bit error rate by using the interface configuration CLI for each of the ports. See the "Configuring the FCS Bit Error Rate Alarm" section on page 3-8 for more information. The severity for this alarm is *error condition*, level 3.

Triggering Alarm Options

The Catalyst 2955 supports three methods for triggering alarms:

- Configurable Relays

  The Catalyst 2955 switch is equipped with two independent alarm relays that can be triggered by alarms for global and port status conditions. The relays can be configured to send a fault signal to an external alarm device, such as a bell, light, or other signaling device. You can associate any alarm condition with either alarm relay or both relays. Each fault condition is assigned a severity level based on the Cisco IOS System Error Message Severity Level.

  See the "Configuring Catalyst 2955 Switch Alarms" section on page 3-4 for more information on configuring the relays.

- SNMP Traps

  SNMP is an application-layer protocol that provides a message format for communication between managers and agents. The SNMP system consists of an SNMP manager, an SNMP agent, and a management information base (MIB).

  The **snmp-server enable traps** command can be modified in the Catalyst 2955 switch software to allow the user to send alarm traps to an SNMP server. You can use alarm profiles to set environmental or port status alarm conditions to send SNMP alarm traps. See the "Enabling SNMP Traps" section on page 3-12 for more information.

- Syslog Messages

  You can use alarm profiles to send system messages to a syslog server. See the "Configuring Catalyst 2955 Switch Alarms" section on page 3-4 for more information.

Configuring Catalyst 2955 Switch Alarms

This section describes how to configure the Catalyst 2955 switch alarms:

- Default Catalyst 2955 Switch Alarm Configuration, page 3-5
- Configuring the Power Supply Alarm, page 3-5
- Configuring the Switch Temperature Alarms, page 3-6
- Configuring the FCS Bit Error Rate Alarm, page 3-8
- Configuring Alarm Profiles, page 3-10
- Enabling SNMP Traps, page 3-12

Default Catalyst 2955 Switch Alarm Configuration

Table 3-3 shows the default Catalyst 2955 switch alarms configuration.

Table 3-3 Default Catalyst 2955 Switch Alarm Configuration

	Alarm	Default Setting
Global	Power Supply Alarm	Enabled in switch single power mode. No alarm. In dual power supply mode, the default alarm notification is a system message to the console.
	Primary Temperature Alarm	Enabled for switch temperature range 95^0C maximum to -20^oC minimum. The primary switch temperature alarm is associated with the major relay.
	Secondary Temperature Alarm	Disabled.
Port	Link Fault Alarm	Disabled on all interfaces.
	Port not Forwarding Alarm	Disabled on all interfaces.
	Port is not Operating Alarm	Enabled on all interfaces.
	FCS Bit Error Rate Alarm	Disabled on all interfaces.

Configuring the Power Supply Alarm

This section describes how to configure the power supply alarm on your switch. It contains this configuration information:

- Setting the Power Mode, page 3-5
- Setting the Power Supply Alarm Options, page 3-6

Setting the Power Mode

The Catalyst 2955 switch has two DC power inputs. By default, the system operates in the single power mode. You can use the **power-supply dual** global configuration command to set the dual mode operation. In dual-power mode, a second power supply gives power to the switch if the primary power supply fails.

Beginning in privileged EXEC mode, follow these steps to set the switch to dual power mode operation:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**power-supply dual**	Set the system to dual mode operation.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show alarm settings**	Verify the configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no power-supply dual** command to disable this alarm by setting the switch back to single power mode operation.

Setting the Power Supply Alarm Options

Use the **alarm facility power-supply** global configuration command to associate the power supply alarm to a relay. You can also configure all alarms and traps associated with the power supply alarm to be sent to syslog and the SNMP server.

Beginning in privileged EXEC mode, follow these steps to associate the power supply alarm to a relay:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**alarm facility power-supply relay** {**major** | **minor**}	Associate the power supply alarm to the major or minor relay.
Step 3	**alarm facility power-supply notifies**	Configure sending power supply alarm traps to an SNMP server.
Step 4	**alarm facility power-supply syslog**	Configure sending power supply alarm traps to a syslog server.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show alarm settings**	Verify the configuration.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable sending the alarm to a relay, to syslog, or to an SNMP server, use the **no alarm facility power-supply relay**, **no alarm facility power-supply notifies**, or **no alarm facility power-supply syslog** global configuration commands.

Note Before you can use the **notifies** command to send alarm traps to an SNMP server, you must first set up the SNMP server by using the **snmp-server enable traps alarms** global configuration command. See the "Enabling SNMP Traps" section on page 3-12.

This example sets the power-supply monitoring alarm to the minor relay.

```
Switch(config) # alarm facility power-supply relay minor
```

Configuring the Switch Temperature Alarms

The temperature thresholds for the primary temperature alarm cannot be changed, but you can change the association of the primary temperature alarm from the major relay to the minor relay. You can also set a lower maximum temperature threshold for the secondary temperature alarm and associate the alarm with either the major or minor relay.

This section describes how to configure the temperature alarms on your switch. It contains this configuration information:

- Setting a Secondary Temperature Threshold for the Switch, page 3-7
- Associating the Temperature Alarms to a Relay, page 3-7

Setting a Secondary Temperature Threshold for the Switch

In global configuration mode, you can use the **alarm facility temperature secondary** command to set a lower temperature threshold for the secondary temperature monitoring alarm. You can also use the **alarm facility temperature secondary** command to associate the secondary temperature alarm to either the major or minor alarm relay.

Beginning in privileged EXEC mode, follow these steps to set a lower temperature threshold:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**alarm facility temperature secondary** *threshold*	Set the secondary temperature threshold value. Enter values from 40 to 95 to set threshold from 40°C to 95°C.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show alarm settings**	Verify the configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no alarm facility temperature secondary** *threshold* global configuration command to disable the secondary temperature threshold alarm.

This example disables the secondary temperature alarm.

```
Switch(config) # no alarm facility temperature secondary 45
```

Associating the Temperature Alarms to a Relay

By default, the primary temperature alarm is associated to the major relay. You can use the **alarm facility temperature** command to associate the primary temperature alarm to the minor relay, to an SNMP trap, to a syslog message, or to associate the secondary temperature alarm to the major or minor relay, an SNMP trap, or a syslog message.

Beginning in privileged EXEC mode, follow these steps to associate the secondary temperature alarm to a relay:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**alarm facility temperature {primary | secondary} relay** {**major** | **minor**}	Associate the primary or secondary temperature alarm to a relay
Step 3	**alarm facility temperature {primary | secondary} notifies**	Configure sending primary or secondary temperature alarm traps to an SNMP server.
Step 4	**alarm facility temperature {primary | secondary} syslog**	Configure sending primary or secondary temperature alarm traps to a syslog server.

	Command	Purpose
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show alarm settings**	Verify the configuration.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note Before you can use the **notifies** command to send alarm traps to an SNMP server, you must first set up the SNMP server by using the **snmp-server enable traps alarms** global configuration command. See the "Enabling SNMP Traps" section on page 3-12.

Use the **no alarm facility temperature secondary** to disable the secondary temperature alarm.

This example sets the secondary temperature alarm to the minor relay, with a lower high temperature threshold value of 45°C. All alarm and traps associated with this alarm will be sent to a syslog server and an SNMP server.

```
Switch(config) # alarm facility temperature secondary 45
Switch(config) # alarm facility temperature secondary relay minor
Switch(config) # alarm facility temperature secondary syslog
Switch(config) # alarm facility temperature secondary notifies
```

This example sets the first (primary) temperature alarm to the major relay. All alarms and traps associated with this alarm will be sent to a syslog server.

```
Switch(config) # alarm facility temperature primary syslog
Switch(config) # alarm facility temperature primary relay major
```

Configuring the FCS Bit Error Rate Alarm

This section describes how to configure the FCS bit error rate alarm on your switch:

- Setting the FCS Error Threshold, page 3-8
- Setting the FCS Error Hysteresis Threshold, page 3-9

Setting the FCS Error Threshold

The switch generates an FCS bit error rate alarm when the actual FCS bit error rate is close to the configured FCS bit error rate. Use the **fcs-threshold** interface configuration command to set the FCS error threshold.

Beginning in privileged EXEC mode, follow these steps to set the bit error rate value for a port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter the number of the switch port to be configured, and the switch enters interface configuration mode.
Step 3	**fcs-threshold** *value*	Set the FCS error rate. For *value*, the range is 6 to 11 to set a maximum bit error rate of $10^{-6}$to 10^{-11}. By default, the FCS bit error rate is 10^{-8}.

	Command	Purpose
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show fcs-threshold**	Verify the setting.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no fcs-threshold** interface configuration command to go back to default FCS threshold value.

This example sets the FCS bit error rate for the Fast Ethernet port 0/1 to 10^{-10}

```
Switch# configure terminal
Switch(config)# interface fastethernet0/1
Switch(config-if) # fcs-threshold 10
```

Setting the FCS Error Hysteresis Threshold

The hysteresis setting prevents the toggle of an alarm when the actual bit error rate fluctuates near the configured bit error rate. Use the **alarm facility fcs-hysteresis** global configuration command to set the FCS error hysteresis threshold.

Note The FCS hysteresis threshold is applied to all ports of a Catalyst 2955 switch.

Beginning in privileged EXEC mode, follow these steps to set the FCS error hysteresis threshold for a switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**alarm facility fcs-hysteresis** *percentage*	Set the hysteresis percentage for the switch. For *percentage*, the range is 1 to 10. The default value is 10 percent.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running config**	Verify the configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note The **show running config** command displays any FCS error hysteresis that is not the default value.

This example sets FCS error hysteresis at 5 percent.

```
Switch(config) # alarm facility fcs-hysteresis 5
```

Configuring Alarm Profiles

This section describes how to configure alarm profiles on your switch. It contains this configuration information:

- Creating or Modifying an Alarm Profile, page 3-10
- Attaching an Alarm Profile to a Specific Port, page 3-11

Creating or Modifying an Alarm Profile

You can use the **alarm profile** global configuration command to create an alarm profile or to modify an existing profile. When you create a new alarm profile, none of the alarms are enabled.

Note The only alarm enabled in the *defaultPort* profile is the Port is not Operating alarm.

Beginning in privileged EXEC mode, follow these steps to create an alarm profile:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**alarm profile** *name*	Create the new profile or identify an existing profile, and then enter alarm profile configuration mode.
Step 3	**alarm** *alarm-id*	Add or modify alarm parameters for a specific alarm (see Table 3-4). The values are 1 to 4. You an enter more than one alarm ID separated by a space.
Step 4	**notifies** *alarm-id*	(Optional) Configure the alarm to send an SNMP trap to an SNMP server.
Step 5	**relay-major** *alarm-id* **relay-minor** *alarm-id*	(Optional) Configure the alarm to send an alarm trap to the major relay. (Optional) Configure the alarm to send an alarm trap to the minor relay.
Step 6	**syslog** *alarm-id*	(Optional) Configure the alarm to send an alarm trap to a syslog server.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show alarm profile** *name*	Verify the configuration.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete an alarm profile, use the **no alarm profile** *name* global configuration command.

This example creates or modifies the alarm profile *fastE* for the fastEthernetPort with link-down (*alarmList* ID 3) and an FCS error rate of 30 percent (*alarmList* ID 4) alarms enabled. The link-down alarm is connected to the minor relay, and the FCS error rate alarm is connected to the major relay. These alarms also send notifications to an SNMP server and send system messages to a syslog server.

```
Switch(config)# alarm profile fastE
Switch(config-alarm- prof)# alarm 3 4
Switch(config-alarm- prof)# relay major 4
Switch(config-alarm- prof)# relay minor 3
Switch(config-alarm- prof)# notifies 3 4
Switch(config-alarm- prof)# syslog 3 4
```

Note Before you can use the **notifies** command to send alarm traps to an SNMP server, you must first set up the SNMP server by using the **snmp-server enable traps alarms** global configuration command. See the "Enabling SNMP Traps" section on page 3-12.

Table 3-4 lists the *alarmList* IDs and their corresponding alarm definitions. For a description of these alarms, see the "Port Status Monitoring Alarms" section on page 3-3.

Table 3-4 AlarmList ID Number Alarm Descriptions

AlarmList ID	Alarm Description
1	Link fault
2	Port not forwarding
3	Port not operating
4	FCS error rate exceeds threshold

Attaching an Alarm Profile to a Specific Port

In interface configuration mode, you can use the **alarm-profile** command to attach an alarm profile to a specific port.

Beginning in privileged EXEC mode, follow these steps to attach an alarm profile to a port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *port interface*	Enter the number of the switch port to be configured, and the switch enters interface configuration mode.
Step 3	**alarm-profile** *name*	Attach the specified profile to the interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show alarm profile**	Verify the configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To detach an alarm profile from a specific port, use the **no alarm-profile** *name* interface configuration command.

This example attaches an alarm profile named *fastE* to the port FastEthernet 0/2.

```
Switch(config)# interface FastEthernet 0/2
Switch(config-if)# alarm profile fastE
```

This example detaches an alarm profile named *fastE* from the port FastEthernet 0/2.

```
Switch(config)# interface FastEthernet 0/2
Switch(config-if)# no alarm profile fastE
```

Enabling SNMP Traps

Use the **snmp-server enable traps alarms** global configuration command to enable the switch to send *alarm* traps.

Note Before using alarm profiles to set the switch to send SNMP alarm trap notifications to an SNMP server, you must first enable SNMP by using the **snmp-server enable traps alarms** global configuration command.

Beginning in privileged EXEC mode, follow these steps to enable the switch to send *alarm* traps:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server enable traps alarms**	Enable the switch to send SNMP traps.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show alarm settings**	Verify the configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Displaying Catalyst 2955 Switch Alarms Status

To display the global and port alarm status, use one or more of the privileged EXEC commands in Table 3-5:

Table 3-5 Commands for Displaying Global and Port Alarm Status

Command	Purpose
show alarm description port	Displays an alarm number and its text description.
show alarm profile [*name*]	Displays all alarm profiles in the system or a specified profile.
show alarm settings	Displays all global alarm settings in the switch.
show env {**all** | **power** | **temperature**}	Displays the status of environmental facilities on the Catalyst 2955 switch.
show alarm status [**critical** | **info** | **major** | **minor**]	Displays generated alarms in the switch.

Getting Started with CMS

This chapter provides these topics about the Cluster Management Suite (CMS) software:

- Features, page 4-2
- Front Panel View, page 4-3
- Topology View, page 4-10
- Menus and Toolbar, page 4-14
- Interaction Modes, page 4-24
- CMS Window Components, page 4-26
- Accessing CMS, page 4-29
- Saving Your Configuration, page 4-31
- Restoring Your Configuration, page 4-32
- CMS Preferences, page 4-32
- Using Different Versions of CMS, page 4-32
- Where to Go Next, page 4-33

This chapter describes CMS on the Catalyst 2950 and Catalyst 2955 switches. Refer to the appropriate switch documentation for descriptions of the web-based management software used on other Catalyst switches.

Note For system requirements and for browser and Java plug-in configuration procedures, refer to the release notes.

Note For a list of CMS features new to this release, select **Help** > **What's New** from the CMS menu bar.

Features

CMS provides these features for managing switch clusters and individual switches from Web browsers such as Netscape Communicator or Microsoft Internet Explorer:

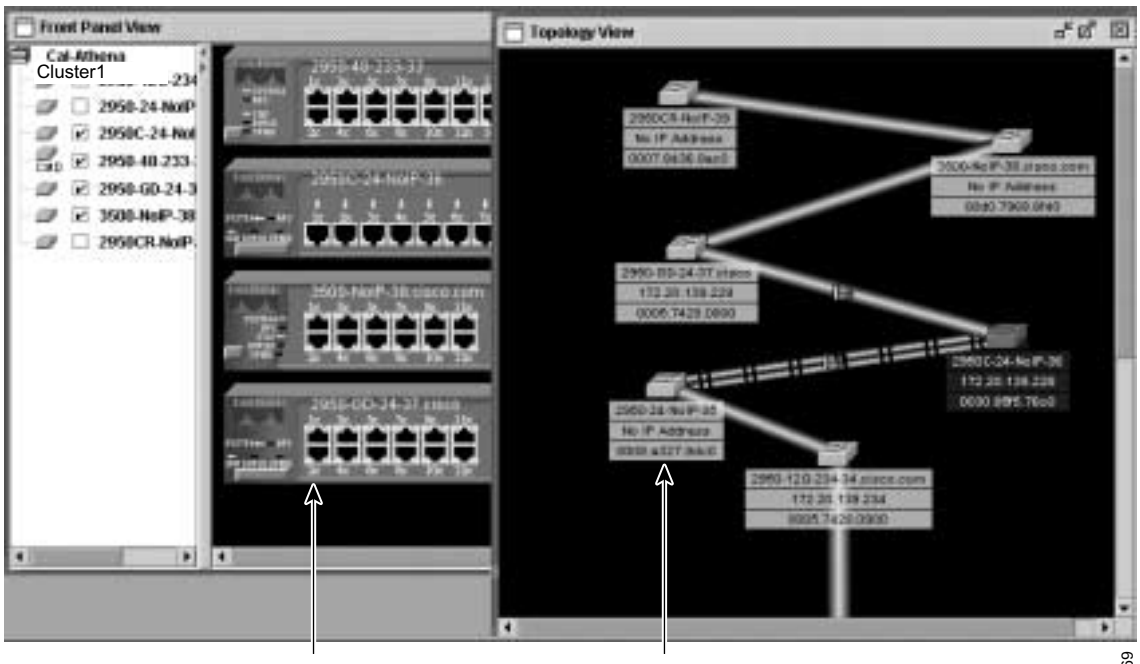
- Two views of your network, as shown in Figure 4-1, that can be displayed at the same time:
  - A Front Panel view that displays the front-panel image of a specific set of switches in a cluster. From this view, you can select multiple ports or multiple switches and configure them with the same settings.

Note When CMS is launched from a command switch, the Front Panel view displays the front-panel image of the command switch. You can select more switches to be displayed. When CMS is launched from a noncommand switch, the Front Panel view displays only the front panel of the specific switch.

  - A Topology view that displays a network map that uses icons representing switch clusters, the command switch, cluster members, cluster candidates, neighboring devices that are not eligible to join a cluster, and link types. From this view, you can select multiple switches and configure them to run with the same settings. You can also display link information in the form of link reports and link graphs.

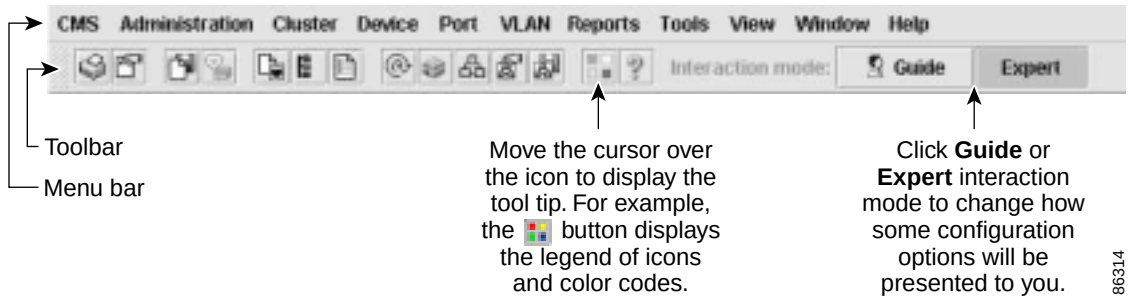
    This view is available only when CMS is launched from a command switch.

Figure 4-1 CMS Front Panel and Topology Views



- Menus and a toolbar, as shown in Figure 4-2, to access configuration and management options:
  - The menu bar provides the complete list of options for managing a single switch and switch clusters.
  - The toolbar provides buttons for commonly used switch and cluster configuration options and information windows such as legends and online help.
  - The port popup menu, in the Front Panel view, provides options specific for configuring and monitoring switch ports.
  - The device popup menu, in either the Front Panel or the Topology view, provides switch and cluster configuration and monitoring options.
  - The candidate, member, and link popup menus provide options for configuring and monitoring devices and links in the Topology view.

Figure 4-2 CMS Menus and Toolbar

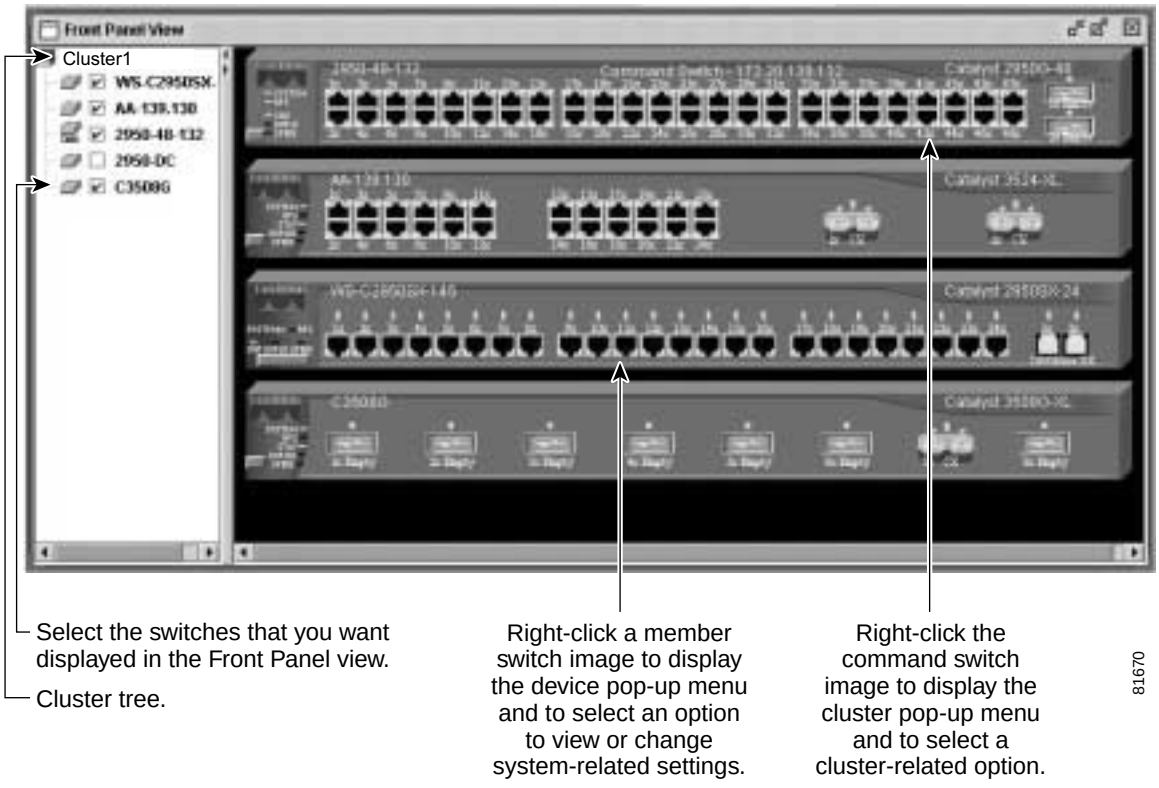


- Tools to simplify configuration tasks:
  - Interactive modes—guide mode and expert mode—that control the presentation of some complex configuration options.
  - Wizards that require minimal information from you to configure some complex features.
  - Comprehensive online help that gives high-level concepts and procedures for performing CMS tasks.
- Two levels of access to the configuration options: read-write access for users allowed to change switch settings and read-only access for users allowed to only view switch settings.
- Consistent set of GUI components (such as tabs, buttons, drop-down lists, and tables) for a uniform approach to viewing and setting configuration parameters.

Front Panel View

When CMS is launched from a command switch, the Front Panel view displays the front-panel image of the command switch, as shown in Figure 4-3. You can select switches to be displayed by checking the boxes in the cluster tree view (left panel of CMS). The switches that are displayed in the tree view can be re-arranged by dragging and dropping them.

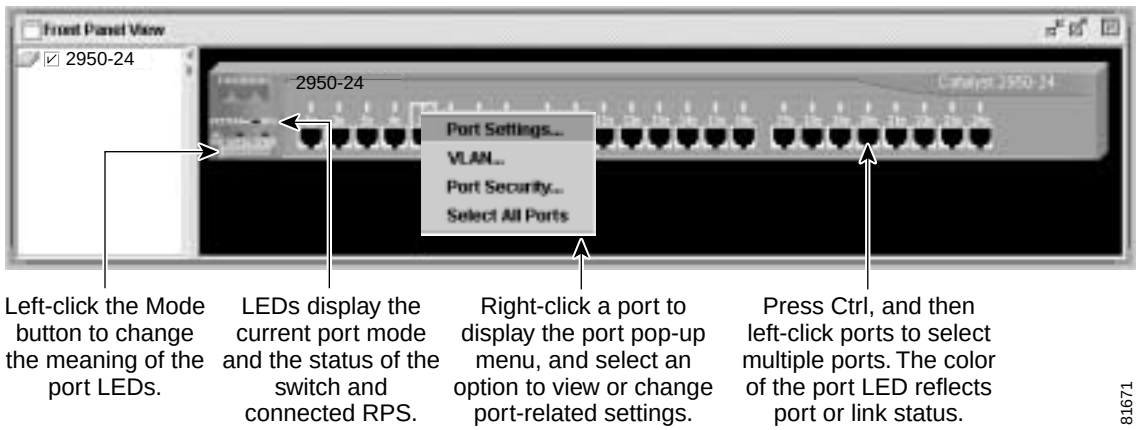
Figure 4-3 Front Panel View from a Command Switch


Front Panel View
Cluster1
WS-C2950SX
AA-139.130
2950-48-132
2950-DC
C3508G
Select the switches that you want displayed in the Front Panel view.
Cluster tree.
Right-click a member switch image to display the device pop-up menu and to select an option to view or change system-related settings.
Right-click the command switch image to display the cluster pop-up menu and to select a cluster-related option.
81670

Note CMS from a standalone switch or from a noncommand switch is referred to as Device Manager (also referred to as Switch Manager). Device Manager is for configuring an individual switch. When you select Device Manager for a specific switch in the cluster, you launch a separate CMS session. The Device Manager interface can vary between the Catalyst switch platforms.

When CMS is launched from a standalone or noncommand member switch, the Front Panel view displays only the front panel of the specific switch, as shown in Figure 4-4.

Figure 4-4 Front Panel View from a Standalone Switch


Front Panel View
2950-24
2950-24
Port Settings...
VLAN...
Port Security...
Select All Ports
Left-click the Mode button to change the meaning of the port LEDs.
LEDs display the current port mode and the status of the switch and connected RPS.
Right-click a port to display the port pop-up menu, and select an option to view or change port-related settings.
Press Ctrl, and then left-click ports to select multiple ports. The color of the port LED reflects port or link status.
81671

Cluster Tree

Figure 4-3 shows the cluster tree that appears in the left frame of the Front Panel view and shows the name of the cluster and a list of its members. Figure 4-5 shows the device icons that you can drag and drop to rearrange them in the cluster tree. The colors of the devices in the cluster tree show the status of the devices, as listed in Table 4-1.

If you want to configure switch or cluster settings on one or more switches, select the appropriate front-panel images.

- To select a front-panel image, click either the cluster-tree icon or the corresponding front-panel image. The front-panel image is then highlighted with a yellow outline.
- To select multiple front-panel images, press the **Ctrl** key, and left-click the cluster-tree icons or the front-panel images. To deselect an icon or image, press the **Ctrl** key, and left-click the icon or image.

If the cluster has many switches, you might need to scroll down the window to display the rest of the front-panel images. Instead of scrolling, you can click an icon in the cluster tree, and CMS then scrolls and displays the corresponding front-panel image.

Figure 4-5 Cluster-Tree Icons

Table 4-1 Cluster Tree Icon Colors

Color	Device Status
Green	Switch is operating normally.
Yellow	The internal fan of the switch is not operating, or the switch is receiving power from an RPS.
Red	Switch is not powered on or has lost power, or the command switch is unable to communicate with the member switch.

Front-Panel Images

You can manage the switch from a remote station by using the front-panel images. The front-panel images are updated based on the network polling interval that you set from **CMS** > **Preferences**.

This section includes descriptions of the LED images. Similar descriptions of the switch LEDs are provided in the switch hardware installation guide.

Note The Preferences window is available if your switch access level is read-only. For more information about the read-only access mode, see the "Access Modes in CMS" section on page 4-30.

Figure 4-6 shows the port icons as they appear in the front-panel images. To select a port, click the port on the Front Panel view. The port is then highlighted with a yellow outline. To select multiple ports, you can:

- Press the left mouse button, drag the pointer over the group of ports that you want to select, and then release the mouse button.
- Press the Ctrl key, and click the ports that you want to select.
- Right-click a port, and select **Select All Ports** from the port popup menu.

Figure 4-6 Port Icons

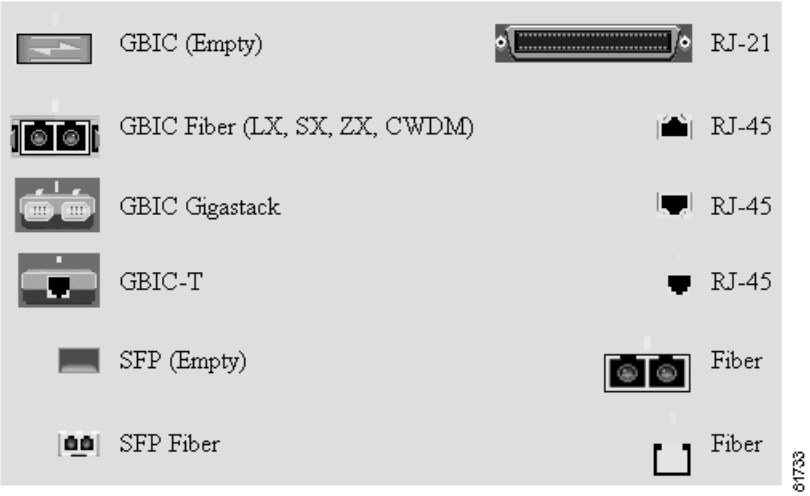


Table 4-2 lists the colors representing the wavelengths on the Coarse Wave Division Multiplexer (CWDM) Gigabit Interface Converter (GBIC) modules. For port status LED information, see the "Port Modes and LEDs" section on page 4-8.

Table 4-2 Port Icon Colors for the CWDM GBIC Module Ports

Wavelength	Color
1470 nanometers (nm)	Gray
1490 nm	Violet
1510 nm	Blue
1530 nm	Green
1550 nm	Yellow
1570 nm	Orange
1590 nm	Red
1610 nm	Brown

Alarm Relay and Power LEDs on Catalyst 2955 Switches

The alarm relay LED images are labeled Alarm MAJ and MIN on the CMS Front Panel view and show when a major or minor alarm has occurred on the switch. You can configure alarm relays for traffic signal failure or degradation, equipment malfunction, and SNMP messages. Red means that an alarm has occurred. No LED, or black, means the absence of alarms on the switch.

Power A and Power B LED images on the CMS Front Panel view for the Catalyst 2955 switch show the status of the primary (A) and secondary (B) power supplies. Green means that the power supply is connected and operating; red means that the power supply is off or not installed. Power B is green only if a secondary power supply is installed and is operating; otherwise, it is red.

Note Refer to the online help for more information about configuring alarm relay settings.

Redundant Power System LED

The Redundant Power System (RPS) LED shows the RPS status, as listed in Table 4-3 and Table 4-4. Certain switches in the switch cluster use a specific RPS model:

- Cisco RPS 300 (model PWR300-AC-RPS-N1)—Catalyst 2900 LRE XL, Catalyst 2950, Catalyst 2950 LRE, Catalyst 3524-PWR XL, and Catalyst 3550 switches
- Cisco RPS 600 (model PWR600-AC-RPS)—Catalyst 2900 XL and Catalyst 3500 XL switches, except the Catalyst 2900 LRE XL and Catalyst 3524-PWR XL switches
- Cisco RPS 675 (model PWR675-AC-RPS-N1=)—Catalyst 2950, Catalyst 2950 LRE, and Catalyst 3550 switches.

Note The Cisco RPS 675 does not support the Catalyst 3550-24-DC switch.

Note The Cisco RPS 300 does not support the Catalyst 2955 switch.

Refer to the appropriate switch hardware documentation for RPS descriptions specific for the switch.

Table 4-3 Cisco RPS 300 and Cisco RPS 675 LED

Color	RPS Status
Black (off)	RPS is off or is not installed.
Green	RPS is connected and operational.
Blinking green	RPS is providing power to another switch in the stack.

Table 4-3 Cisco RPS 300 and Cisco RPS 675 LED (continued)

Color	RPS Status
Amber	The RPS could be in standby mode. To put the RPS in Active mode, press the Standby/Active button on the RPS, and the LED should turn green. If it does not, one of these conditions could exist: • One of the RPS power supplies could be down. Contact Cisco Systems. • The RPS fan could have failed. Contact Cisco Systems.
Blinking amber	Internal power supply of the switch is down, and redundancy is lost. The switch is operating on the RPS.

Table 4-4 Cisco RPS 600 LED

Color	RPS Status
Black (off)	RPS is off or is not installed.
Green	RPS is operational.
Blinking green	RPS and the switch AC power supply are both powered up. If the switch power supply fails, the switch powers down and after 15 seconds restarts, using power from the RPS. The switch goes through its normal boot sequence when it restarts. **Note** This is not a recommended configuration.
Amber	RPS is connected but not functioning properly. One of the power supplies in the RPS could be powered down, or a fan on the RPS could have failed.

Port Modes and LEDs

Table 4-5 and Table 4-6 list the port modes that determine the type of information displayed through the port LEDs. When you change port modes, the meanings of the port LED colors also change.

Note The bandwidth utilization mode (UTIL LED) does not appear on the front-panel images. Select **Reports > Bandwidth Graphs** to display the total bandwidth in use by the switch. Refer to the switch hardware installation guide for information about using the UTIL LED.

To select or change a mode, click the Mode button until the desired mode LED is green.

Note The Catalyst 2955 switch does not have a Mode button. Port status is shown by the LED color that surrounds the port image.

Table 4-5 Port Modes

Mode LED	Description
STAT	Link status of the ports. Default mode.
DUPLX	Duplex setting on the ports. The default setting on the 10/100 ports is auto. The default setting on the 10/100/1000 ports is full.
SPEED	Speed setting on the ports. The default setting on the 10/100 and 10/100/1000 ports is auto.

Table 4-6 Port LEDs

Port Mode	Port LED Color	Description
STAT	Cyan (off)	No link.
	Green	Link present.
	Amber	Link fault. Error frames can affect connectivity, and errors such as excessive collisions, CRC errors, and alignment and jabber errors are monitored for a link-fault indication. Port is not forwarding. Port was disabled by management, by an address violation, or by Spanning Tree Protocol (STP). **Note** After a port is reconfigured, the port LED can remain amber for up to 30 seconds as STP checks the switch for possible loops.
	Brown	No link. Port is administratively shut down.
DUPLX	Cyan (off)	Port is operating in half-duplex mode.
	Green	Port is operating in full-duplex mode.
SPEED	Cyan (off)	Port is operating at 10 Mbps (10/100 ports) or no link (10/100/1000 ports and GBIC module ports).
	Green	Port is operating at 100 Mbps (10/100 ports) or 1000 Mbps (GBIC module ports).
	Blinking green	Port is operating at 1000 Mbps (10/100/1000 ports).

VLAN Membership Modes

Table 4-7 lists the colors that outline the ports (Front Panel view) when you click **Highlight VLAN Port Membership Modes** on the Configure VLANs tab on the VLAN window. The colors show the VLAN membership mode of each port. The VLAN membership mode determines the kind of traffic the port carries and the number of VLANs to which it can belong. For more information about these modes, see the "VLAN Port Membership Modes" section on page 15-3.

Note This feature is not supported on the Catalyst 1900 and Catalyst 2820 switches.

Table 4-7 VLAN Membership Modes

Mode	Color
Static access	Light green
Dynamic access	Pink
802.1Q trunk	Peach
Negotiate trunk	White

Topology View

The Topology view displays how the devices within a switch cluster are connected and how the switch cluster is connected to other clusters and devices. From this view, you can add and remove cluster members. This view provides two levels of detail of the network topology:

- Expand Cluster: When you right-click a cluster icon and select Expand Cluster, the Topology view displays the switch cluster in detail, as shown in Figure 4-7. This view shows the command switch and member switches in a cluster. It also shows candidate switches that can join the cluster. This view does not display the details of any neighboring switch clusters
- Collapse Cluster: When you right-click a command-switch icon and select Collapse Cluster, the cluster is collapsed and represented by a single icon, as shown in Figure 4-8. The view shows how the cluster is connected to other clusters, candidate switches, and devices that are not eligible to join the cluster (such as routers, access points, IP phones, and so on).

Note The Topology view displays only the switch cluster and network neighborhood of the specific command or member switch that you access. To display a different switch cluster, you need to access the command switch or member switch of that cluster.

You can arrange the device icons in either view. To move a device icon, click and drag the icon. To select multiple device icons, you can either:

- Press the left mouse button, drag the pointer over the group of device icons that you want to select, and then release the mouse button.
- Press the Ctrl key, and click the device icons that you want to select.

After selecting the icons, drag the icons to any area in the view.

Figure 4-7 Expand Cluster View

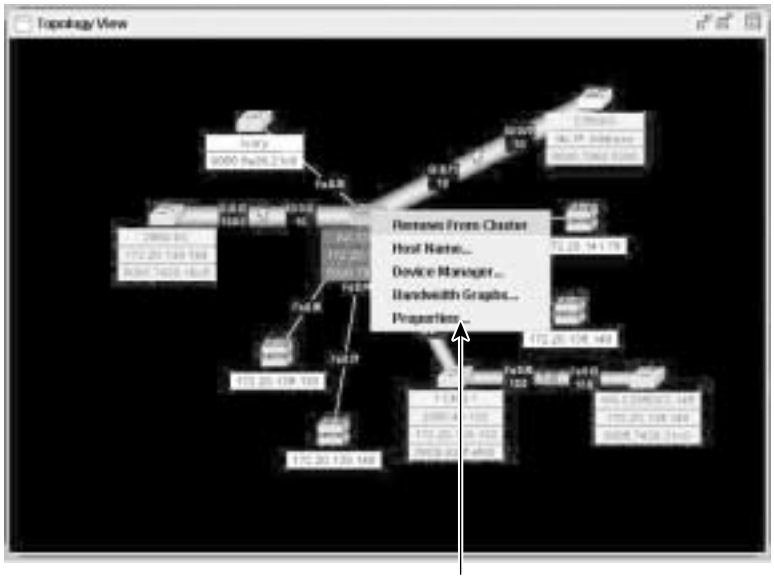
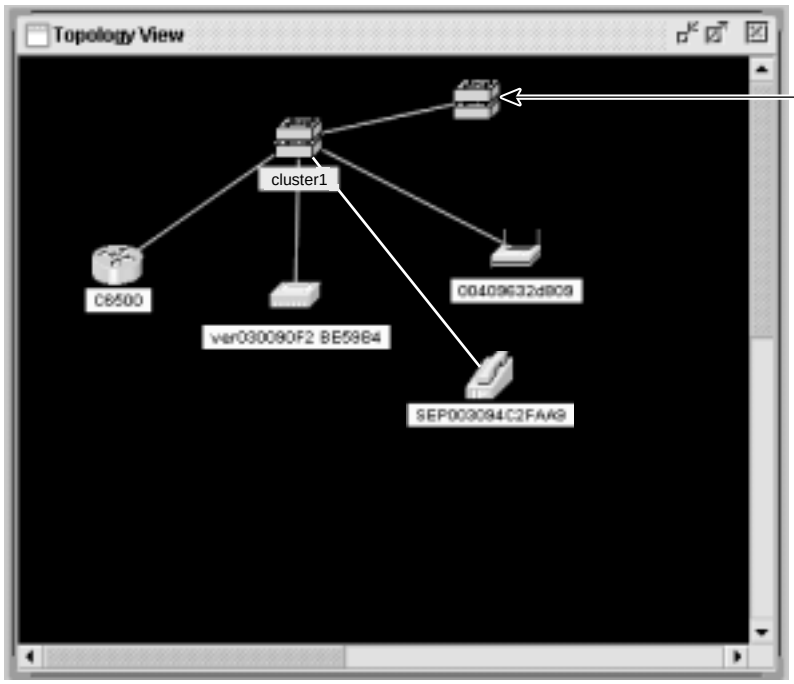


Figure 4-8 Collapse Cluster View



Topology Icons and Labels

The Topology view and the cluster tree use the same set of device icons to represent clusters, command and standby command switches, and member switches. They also use the same labels to identify the command switch (**CMD**) and the standby command switch (**STBY**).

The Topology view uses additional icons to represent these types of neighboring devices:

- Customer premises equipment (CPE) devices that are connected to Long-Reach Ethernet (LRE) switches
- Devices that are not eligible to join the cluster, such as Cisco IP Phones, Cisco access points, and Cisco Discovery Protocol (CDP)-capable hubs and routers

Note The System Switch Processor (SSP) card in the Cisco Integrated Communications System (ICS) 7750 appears as a Layer 2 switch. SSP cards are not eligible to join switch clusters.

- Devices that are identified as unknown devices, such as some Cisco devices and third-party devices

Tip Neighboring devices are only displayed if they are connected to cluster members. To display neighboring devices in the Topology view, either add the switch to which they are connected to a cluster, or enable that switch as a command switch.

Note Candidate switches are distinguished by the color of their device label. Device labels and their colors are described in the "Colors in the Topology View" section on page 4-13.

To select a device, click the icon. The icon is then highlighted. To select multiple devices, you can either:

- Press the left mouse button, drag the pointer over the group of icons that you want to select, and then release the mouse button.
- Press the **Ctrl** key, and click the icons that you want to select.

The Topology view also uses a set of link icons to show the link type and status between two devices. To select a link, click the link that you want to select. To select multiple links, press the Ctrl key, and click the links that you want to select.

Device and Link Labels

The Topology view displays device and link information by using these labels:

- Cluster and switch names
- Switch MAC and IP addresses
- Link type between the devices
- Link speed and IDs of the interfaces on both ends of the link

When using these labels, keep these considerations in mind:

- The IP address displays only in the labels for the command switch and member switches.
- The label of a neighboring cluster icon only displays the IP address of the command-switch IP address.
- The link speeds displayed are the actual link speeds except on the LRE links, which display the administratively assigned speed settings.

You can change the label settings from the Topology Options window by selecting **View** > **Topology Options**.

Colors in the Topology View

The colors of the Topology view icons show the status of the devices and links, as listed in Table 4-8, Table 4-9, and Table 4-10.

Table 4-8 Device Icon Colors

Icon Color	Color Meaning
Green	The device is operating.
Yellow[1]	The internal fan of the switch is not operating, or the switch is receiving power from an RPS.
Red[1]	The device is not operating.

1. Available only on the cluster members.

Table 4-9 Single Link Icon Colors

Link Color	Color Meaning
Green	Active link
Red	Down or blocked link

Table 4-10 Multiple Link Icon Colors

Link Color	Color Meaning
Both green	All links are active.
One green; one red	At least one link is active, and at least one other link is down or blocked.
Both red	All links are down or blocked.

The color of a device label shows the cluster membership of the device, as listed in Table 4-11.

Table 4-11 Device Label Colors

Label Color	Color Meaning
Green	A cluster member, either a member switch or the command switch
Cyan	A candidate switch that is eligible to join the cluster
Yellow	An unknown device or a device that is not eligible to join the cluster

Topology Display Options

You can set the type of information displayed in the Topology view by changing the settings in the Topology Options window. To display this window, select **View** > **Topology Options**. From this window, you can select:

- Device icons (including IP Phones, CPEs, Neighbors, Access Points, and Candidates) that you want displayed in or filtered from the Topology View window
- Interface IDs and Actual Speed values that you want displayed in the Link window
- Host Names, IP addresses, and MAC address labels that you want displayed in the Node window

Menus and Toolbar

The configuration and monitoring options for configuring switches and switch clusters are available from menus and a toolbar.

Menu Bar

The menu bar, as shown in Figure 4-2, provides the complete list of options for managing a single switch and switch cluster.

The menu-bar options on a Catalyst 2950 or Catalyst 2955 switch change depending on whether the switch is running the standard software image (SI) or the enhanced software image (EI). The footnotes in Table 3-11 list the options available if the switch is running the EI.

Note The Catalyst 2955 switch runs only the EI.

Options displayed from the menu bar can vary:

- The option for enabling a command switch is only available from a CMS session launched from a command-capable switch.
- Cluster management tasks, such as upgrading the software of groups of switches, are available only from a CMS session launched from a command switch.
- If you launch CMS from a specific switch, the menu bar displays the features supported only by that switch.

- If you launch CMS from a command switch, the menu bar displays the features supported on the switches in the cluster, with these exceptions:
  - If the command switch is a Layer 3 switch, such as a Catalyst 3550 switch, the menu bar displays the features of all Layer 3 and Layer 2 switches in the cluster.
  - If the command switch is a Layer 2 switch, such as a Catalyst 2950 or Catalyst 3500 XL switch, the menu bar displays the features of all Layer 2 switches in the cluster. The menu bar does not display Layer 3 features even if the cluster has Catalyst 3550 Layer 3 member switches.
- We strongly recommend that the highest-end, command-capable switch in the cluster be the command switch:
  - If your switch cluster has a Catalyst 3550 switch, that switch should be the command switch.
  - If your switch cluster has Catalyst 2900 XL, Catalyst 2950, Catalyst 2955, and Catalyst 3500 XL switches, the Catalyst 2950 or Catalyst 2955 switch should be the command switch.
  - If your switch cluster has Catalyst 1900, Catalyst 2820, Catalyst 2900 XL, and Catalyst 3500 XL switches, either the Catalyst 2900 XL or Catalyst 3500 XL switch should be the command switch.
- Standby command switches must meet these requirements:
  - When the command switch is a Catalyst 3550 switch, all standby command switches must be Catalyst 3550 switches.
  - When the command switch is a Catalyst 2955 switch running Release 12.1(12c)EA1 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(12c)EA1 or later.
  - When the command switch is a Catalyst 2950 switch running Release 12.1(9)EA1 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(9)EA1 or later.
- When the command switch is a Catalyst 2950 switch running Release 12.1(6)EA2 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(6)EA2 or later.
  - When the command switch is running Release 12.0(5)WC2 or earlier, the standby command switches can be these switches: Catalyst 2900 XL, Catalyst 2950, and Catalyst 3500 XL switches.

We strongly recommend that the command switch and standby command switches are of the same switch platform and that both are running the same level of software (SI or EI). In the event of a failover, the standby command switch must support the same configuration and services that are running on the command switch.

Refer to the release notes for the Catalyst switches that can be part of a switch cluster.

Unless noted otherwise, the menu-bar options in the list that follows are available from a Catalyst 2950 or Catalyst 2955 command switch when the cluster contains only Catalyst 2950 or Catalyst 2955 member switches. The menu bar of the command switch displays all menu-bar options available from the cluster, including options from member switches from other cluster-capable switch platforms.

Note Access modes affect the availability of features from CMS. Some CMS features are not available in read-only mode. For more information about how access modes affect CMS, see the "Access Modes in CMS" section on page 4-30.

These are the menu bar options:

- **CMS**
  - **Page Setup**—Set default document printer properties to be used when printing from CMS.
  - **Print Preview**—View the way the CMS window or help file will appear when printed.
  - **Print**—Print a CMS window or help file.
  - **Guide Mode**/**Expert Mode**—Select which interaction mode to use when you select a configuration option (not available in read-only mode).
  - **Preferences**—Set CMS display properties, such as polling intervals, the default views to open at startup, and the color of administratively shutdown ports. Some options from this menu are not available in read-only mode.
- **Administration**
  - **IP Addresses**—Configure IP information for a switch. Some options from this menu are not available in read-only mode.
  - **SNMP**—Enable and disable Simple Network Management Protocol (SNMP), enter community strings, and configure end stations as trap managers. Some options from this menu are not available in read-only mode.
  - **System Time**—Configure the system time or configure the Network Time Protocol (NTP). Some options from this menu are not available in read-only mode.
  - **HTTP Port**—Configure the Hypertext Transfer Protocol (HTTP) port number. Some options from this menu are not available in read-only mode.
  - **Users and Passwords**—Configure usernames and passwords for privilege levels 0 to 15.
  - **Console Baud Rate**—Change the baud rate for the switch console port. Some options from this menu are not available in read-only mode.
  - **MAC Addresses**—Enter dynamic, secure, and static addresses in a switch address table. You can also define the forwarding behavior of static addresses. Some options from this menu are not available in read-only mode.
  - **ARP**—Display the device Address Resolution Protocol (ARP) table, and configure the ARP cache timeout setting. Some options from this menu are not available in read-only mode.
  - **Save Configuration**—Save the configuration for the cluster or switch to Flash memory (not available in read-only mode).
  - **Restore Configuration**—Restore the configuration file to one or more switches in the cluster.
  - **Software Upgrade**—Upgrade the software for the cluster or a switch (not available in read-only mode).
  - **System Reload**—Reboot the switch with the latest installed software (not available in read-only mode).
  - **Event Notification**—Create notification IDs that generate e-mail notifications when system events occur.
- **Cluster**
  - **Cluster Manager**—Launch a CMS session from the member switch (available only from a Device Manager session on a cluster member).
  - **Create Cluster**—Designate a command switch, and name a cluster (not available in read-only mode). This option is available only from a Device Manager session on a command-capable switch that is not a cluster member.

  - **Delete Cluster**—Delete a cluster (not available in read-only mode). This option is available only from a cluster management session.
  - **Add to Cluster**—Add a candidate to a cluster (not available in read-only mode). This option is available only from a cluster management session.
  - **Remove from Cluster**—Remove a member from the cluster (not available in read-only mode) This option is available only from a cluster management session.
  - **Standby Command Switches**—Create a Hot Standby Router Protocol (HSRP) standby group to provide command-switch redundancy. Some options from this menu are not available in read-only mode. This option is available only from a cluster management session.
  - **Hop Count**—Enter the number of hops away that a command switch looks for members and for candidate switches. Some options from this menu are not available in read-only mode. This option is available only from a cluster management session.

- **Device**
  - **Device Manager**—Launch Device Manager for a specific switch. This option is available only from a cluster management session (Catalyst 1900 and Catalyst 2820 member switches only).
  - **Host Name**—Change the host name of a switch (not available in read-only mode).
  - **Alarms** (Catalyst 2955 only)—Configure alarm settings for an interface or for the entire device, and view the status of any unresolved alarms.
  - **STP**—Display and configure STP parameters for a switch. Some options from this menu are not available in read-only mode.
  - **IGMP Snooping**—Enable and disable Internet Group Management Protocol (IGMP) snooping and IGMP Immediate-Leave processing on the switch. Join or leave multicast groups, and configure multicast routers. Some options from this menu are not available in read-only mode.
  - **802.1X**—Configure 802.1X authentication of devices as they are attached to LAN ports in a point-to-point infrastructure (not available in read-only mode).
  - **ACL** (guide mode available in read-write mode)—Create and maintain access control lists (ACLs), and attach ACLs to specific ports. Some options from this menu are not available in read-only mode.
  - This option is available only from a switch running the EI.
  - **Security Wizard**—Filter certain traffic, such as HTTP traffic, to certain networks or devices. Restrict access to servers, networks, or application data from certain networks or devices (not available in read-only mode).
  - This option is available only from a switch running the EI.
  - **QoS**—Display submenu options to configure, enable, and disable quality of service (QoS) parameters for Trust settings, Queues, Maps, Classes (guide mode available), and Policies (guide mode available. Some options from this menu are not available in read-only mode.
  - **AVVID Wizards**—Configure a port to send or receive voice traffic by using the Voice Wizard. Optimize multiple video servers for sending video traffic by using the Video Wizard. Provide a higher priority to specific applications by using the Data Wizard.

Note AVVID Wizards are not available in read-only mode.

- **Port**
  - **Port Settings**—Display and configure port parameters on a switch. Some options from this menu are not available in read-only mode.
  - **Port Search**—Search for a port through its description.
  - **Port Security**—Enable port security on a port (not available in read-only mode).
  - **EtherChannels**—Group ports into logical units for high-speed links between switches. Some options from this menu are not available in read-only mode.
  - **SPAN**—Enable Switched Port Analyzer (SPAN) port monitoring. Some options from this menu are not available in read-only mode.
  - **Protected Port**—Configure a port to prevent it from receiving bridged traffic from another port on the same switch. Some options from this menu are not available in read-only mode.
  - **Flooding Control**—Block the normal flooding of unicast and multicast packets and enable the switch to block packet storms. Some options from this menu are not available in read-only mode.
- **VLAN**
  - **VLAN** (guide mode available in read-write mode)—Display VLAN membership, assign ports to VLANs, and configure 802.1Q trunks. Display and configure the VLAN Trunking Protocol (VTP) for interswitch VLAN membership. Some options from this menu are not available in read-only mode.
  - **Management VLAN**—Change the management VLAN on the switch. Some options from this menu are not available in read-only mode.
  - **VMPS**—Configure the VLAN Membership Policy Server (VMPS). Some options from this menu are not available in read-only mode.
  - **Voice VLAN**—Configure a port to use a voice VLAN for voice traffic, separating it from the VLANs for data traffic. Some options from this menu are not available in read-only mode.
- **Reports**
  - **Inventory**—Display the device type, software version, IP address, and other information about a switch.
  - **Port Statistics**—Display port statistics.
  - **Bandwidth Graphs**—Display graphs that plot the total bandwidth in use by the switch.
  - **Link Graphs**—Display a graph showing the bandwidth being used for the selected link.
  - **Link Reports**—Display the link report for two connected devices. If one device is an unknown device or a candidate, only the cluster-member side of the link appears.
  - **ACL Reports**—Display a report about ACL statistics.
  - **Multicast**—Display a submenu to run an IGMP report.
  - **Resource Monitor**—Display masks for ACL and QoS policy maps. This option is available only from a switch running the EI.
  - **System Messages**—Display the most recent system messages (IOS messages and switch-specific messages) sent by the switch software.

    This option is available on the Catalyst 2950, Catalyst 2955, and Catalyst 3550 switches. It is not available from the Catalyst 2900 XL and Catalyst 3500 XL switches. You can display the system messages of the Catalyst 2900 XL and Catalyst 3500 XL switches when they are in a

cluster where the command switch is a Catalyst 2950 switch running Release 12.1(6)EA2 or later, Catalyst 2955 switch running Release 12.1(12c)EA1 or later, or a Catalyst 3550 switch running Release 12.1(8)EA1 or later.

For more information about system messages, refer to the switch system message guide for that release.

- **Tools**
  - **Ping and Trace**—Perform a ping or Layer 2 traceroute operation on or to a specific address.
- **View**
  - **Refresh**—Update the views with the latest status.
  - **Front Panel**—Display the Front Panel view.
  - **Topology**—Display the Topology view. This option is available only from a cluster management session.
  - **Topology Options**—Select the information to be displayed in the Topology view.
  - **Automatic Topology Layout—**Request CMS to rearrange the topology layout. This option is available only from a cluster management session.
  - **Save Topology Layout**—Save the presentation of the cluster icons that you arranged in the Topology view to Flash memory (not available in read-only mode). This option is available only from a cluster-management session.
- **Window**—List the open windows in your CMS session.
- **Help**
  - **Overview**—Obtain an overview of the CMS interface.
  - **What's New**—Obtain a description of the new CMS features.
  - **Help For Active Window**—Display the help for the active open window. You can also click **Help** from the active window.
  - **Contents**—List all of the available online help topics.
  - **Legend**—Display the legend that describes the icons, labels, and links.
  - **About**—Display the CMS version number.

Toolbar

The toolbar buttons display commonly-used switch and cluster configuration options and information windows such as legends and online help. Hover the cursor over an icon to display the feature. Table 4-12 lists the toolbar options from left to right on the toolbar.

Table 4-12 Toolbar Buttons

Toolbar Option	Icon	Keyboard Shortcut	Task
Print		Ctrl-P	Print a CMS window or help file.
Preferences[1]		Ctrl-R	Set CMS display properties, such as polling intervals, the views to open at CMS startup, and the color of administratively shut down ports.

Table 4-12 Toolbar Buttons (continued)

Toolbar Option	Icon	Keyboard Shortcut	Task
Save Configuration[2]		Ctrl-S	Save the configuration of the cluster of a switch to Flash memory.
Software Upgrade[2]		Ctrl-U	Upgrade the software for the cluster or a switch.
Port Settings[1]		—	Display and configure port parameters on a switch.
VLAN[1]		Ctrl-V	Display VLAN membership, assign ports to VLANs, and change the administration mode.
Inventory		Ctrl-T	Display the device type, the software version, the IP address, and other information about a switch.
Refresh		—	Update the views with the latest status.
Front Panel		—	Display the Front Panel view.
Topology[3]		—	Display the Topology view.
Topology Options[3]		—	Select the information to be displayed in the Topology view.
Save Topology[2] [3] Layout		—	Save the presentation of the cluster icons that you arranged in the Topology view to Flash memory.
Legend		—	Display the legend that describes the icons, labels, and links.
Help for Active Window		F1 key	Display the help for the active open window. You can also click **Help** from the active window.

1. Not available in read-only mode. For more information about the read-only and read-write access modes, see the "Access Modes in CMS" section on page 4-30.
2. Some options from this menu option are not available in read-only mode.
3. Available only from a cluster-management session.

Front Panel View Popup Menus

These popup menus are available in the Front Panel view:

Device Popup Menu

You can display all switch and cluster configuration windows from the menu bar, or you can display commonly-used configuration windows from the device popup menu, as listed in Table 4-13. To display the device popup menu, click the switch icon from the cluster tree or the front-panel image itself, and right-click.

Table 4-13 Device Popup Menu

Popup Menu Option	Task
Device Manager[1]	Launch Device Manager for the switch.
Host Name[2]	Change the name of the switch.
Delete Cluster[2 3 4]	Delete a cluster.
Remove from Cluster[2 4]	Remove a member from the cluster.
Bandwidth Graphs	Display graphs that plot the total bandwidth in use.
Properties	Display information about the device and port on either end of the link and the state of the link.

1. Available from a cluster member switch but not from the command switch.
2. Not available in read-only mode. For more information about the read-only mode, see the "Access Modes in CMS" section on page 4-30.
3. Available only from the command switch.
4. Available only from a cluster-management session.

Port Popup Menu

You can display all port configuration windows from the Port menu on the menu bar, or you can display commonly-used port configuration windows from the port popup menu, as listed in Table 4-14. To display the port popup menu, click a specific port image, and right-click.

Table 4-14 Port Popup Menu

Popup Menu Option	Task
Port Settings[1]	Display and configure port settings.
VLAN[1]	Define the VLAN mode for a port or ports and add ports to VLANs. Not available for the Catalyst 1900 and Catalyst 2820 switches.
Port Security[1 2 3]	Enable port security on a port.
Link Graphs[4]	Display a graph showing the bandwidth used by the selected link.
Select All Ports	Select all ports on the switch for global configuration.

1. Some options from this menu are not available in read-only mode.
2. Available on switches that support the Port Security feature.
3. This feature is not available in read-only mode.
4. Available only when there is an active link on the port (that is, the port LED is green when in port status mode).

Topology View Popup Menus

These popup menus are available in the Topology view.

Link Popup Menu

Table 4-15 lists the reports and graphs that you can display for a specific link in the Topology view. To display the link popup menu, click the link icon, and right-click.

Table 4-15 Link Popup Menu

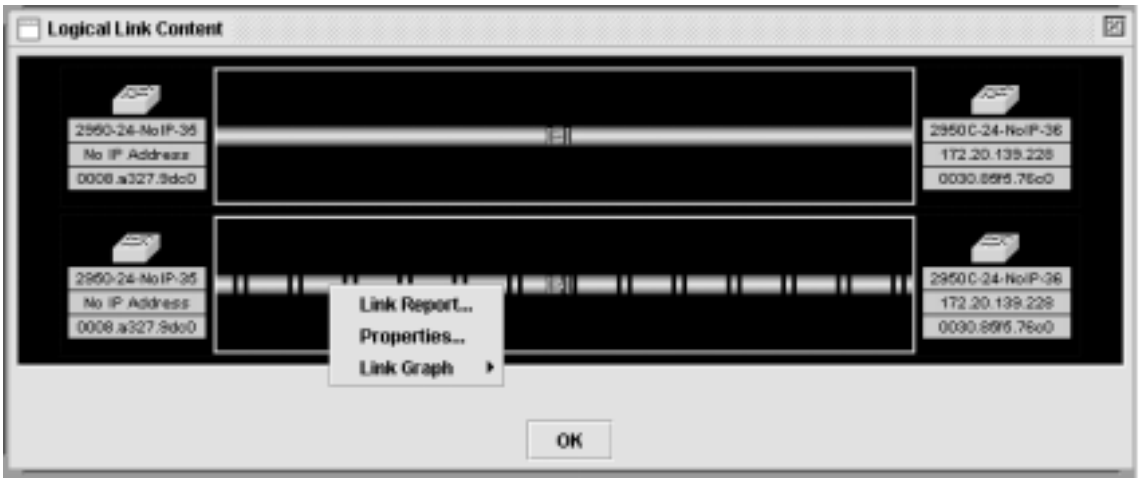
Link Popup Menu	Task
Link Report	Display the link report for two connected devices. If one device is an unknown device or a candidate, only the cluster member side of the link displays.
Link Graph	Display a graph showing the current bandwidth used by the selected link. You can change the graph polling interval by selecting **CMS** > **Preferences**.
Properties	Display information about the device and port on either end of the link and the state of the link.

The Link Report and Link Graph options are not available if at both ends of the link are one of these:

- Candidate switches
- Catalyst 1900 and Catalyst 2820 switches
- Devices that are not eligible to join the cluster

If multiple links are configured between two devices, when you click the link icon and right-click, the Logical Link Content window appears, as shown in Figure 4-9. Click the link icon in this window, and right-click to display the link popup menu specific for that link.

Figure 4-9 Logical Link Window



Device Popup Menus

Table 4-16 through Table 4-21 list the popup menus for specific devices:

- Cluster (Table 4-16)
- Command switch (Table 4-17)
- Member or standby command switch (Table 4-18)
- Candidate switch with an IP address (Table 4-19)

- Candidate switch without an IP address (Table 4-20)
- Neighboring devices (Table 4-21)

Note The Device Manager option in these popup menus is available in read-only mode on Catalyst 2900 XL and Catalyst 3500 XL switches running Release 12.0(5)WC2 and later. It is also available on Catalyst 2950 switches running Release 12.1(6)EA2 or later, Catalyst 2955 switches running Release 12.1(12c)EA1 or later, and on Catalyst 3550 switch running Release 12.1(8)EA1 or later. It is not available on the Catalyst 1900 and Catalyst 2820 switches.

To display a device popup menu, click an icon, and right-click.

Table 4-16 Cluster Icon Popup Menu

Popup Menu Option	Task
Expand cluster	View a cluster-specific topology view.
Properties	Display information about the device.

Table 4-17 Command-Switch Icon Popup Menu

Popup Menu Option	Task
Collapse cluster	View the neighborhood outside a specific cluster.
Host Name	Change the host name of a switch.
Bandwidth Graphs	Display graphs that plot the total bandwidth in use by the switch.
Properties	Display information about the device.

Table 4-18 Member or Standby Command-Switch Icon Popup Menu

Popup Menu Option	Task
Remove from Cluster	Remove a member from the cluster.
Host Name1	Change the host name of a switch.
Device Manager	Launch Device Manager for a switch.
Bandwidth Graphs	Display graphs that plot the total bandwidth in use by the switch.
Properties	Display information about the device.

Table 4-19 Candidate-Switch Icon Popup Menu (When the Candidate Switch Has an IP Address)

Popup Menu Option	Task
Add to Cluster	Add a candidate to a cluster.
Device Manager	Launch Device Manager for a switch.
Properties	Display information about the device.

Table 4-20 Candidate-Switch Icon Popup Menu (When the Candidate Switch Does Not Have an IP Address)

Popup Menu Option	Task
Add to Cluster	Add a candidate to a cluster.
Properties	Display information about the device.

Table 4-21 Neighboring-Device Icon Popup Menu

Popup Menu Option	Task
Device Manager	Access the web management interface of the device. **Note** This option is available on Cisco access points, but not on Cisco IP Phones, hubs, routers and on unknown devices such as some Cisco devices and third-party devices.
Disqualification Code	Display the reason why the device could not join the cluster.
Properties	Display information about the device.

Interaction Modes

You can change the interaction mode of CMS to either guide or expert mode. Guide mode steps you through each feature option and provides information about the parameter. Expert mode displays a configuration window in which you configure the feature options.

Note You cannot switch modes for an open CMS window (for example, from Guide Mode to Expert Mode). For the mode change to take effect on any other open CMS window, you need to close that window and then re-open it after you select the new mode.

Guide Mode

Guide mode is for users who want a step-by-step approach for completing a specific configuration task. This mode is not available for all features. A menu-bar option that has a person icon means that guide mode is available for that option.

When you click **Guide Mode** and then select a menu-bar option that supports it , CMS displays a specific parameter of the feature with information about the parameter field. To configure the feature, you provide the information that CMS requests in each step until you click **Finish** in the last step. Clicking **Cancel** at any time closes and ends the configuration task without applying any changes.

If **Expert Mode** is selected and you want to use Guide Mode instead, you must click Guide Mode *before* selecting an option from the menu bar, tool bar, or popup menu. If you change the interaction mode after selecting a configuration option, the mode change does not take effect until you select another configuration option.

Note Guide mode is not available if your switch access level is read-only. For more information about the read-only access mode, see the "Access Modes in CMS" section on page 4-30.

Expert Mode

Expert mode is for users who prefer to display all the parameter fields of a feature in a single CMS window. Information about the parameter fields is available by clicking the Help button.

Wizards

Wizards simplify some configuration tasks on the switch. Similar to the guide mode, wizards provide a step-by-step approach for completing a specific configuration task. Unlike guide mode, a wizard does not prompt you to provide information for all of the feature options. Instead, it prompts you to provide minimal information and then uses the default settings of the remaining options to set up default configurations.

Wizards are not available for all features. A menu-bar option that has wizard means that selecting that option launches the wizard for that feature.

Note Wizards are not available if your switch access level is read-only. For more information about the read-only access mode, see the "Access Modes in CMS" section on page 4-30.

Tool Tips

CMS displays a popup message when you move your mouse over these devices:

- A yellow device icon in the cluster tree or in Topology view—A popup displays a fault message, such as that the RPS is faulty or that the switch is unavailable because you are in read-only mode.
- A red device icon in the cluster tree or in Topology view—A popup displays a message that the switch is down.

If you move your mouse over a table column heading, a popup displays the full heading.

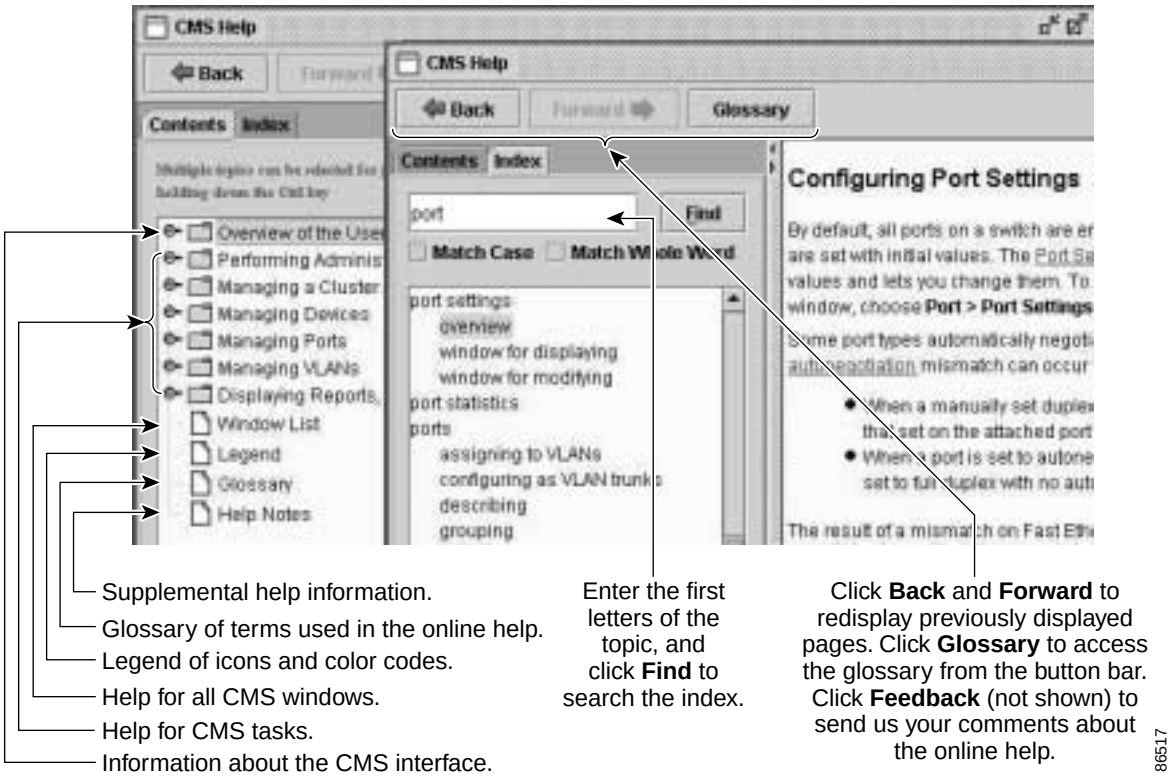
Online Help

CMS provides comprehensive online help to assist you in understanding and performing configuration and monitoring tasks from the CMS windows, as shown in Figure 4-10. Online help includes these features:

- Feature help, available from the menu bar by selecting **Help** > **Contents**, provides background information and concepts on the features.
- Dialog-specific help, available from Help on the CMS windows, provides procedures for performing tasks.
- Index of help topics.
- Glossary of terms used in the online help.

You can send us feedback about the information provided in the online help. Click **Feedback** to display an online form. After completing the form, click **Submit** to send your comments to Cisco Systems Inc. We appreciate and value your comments.

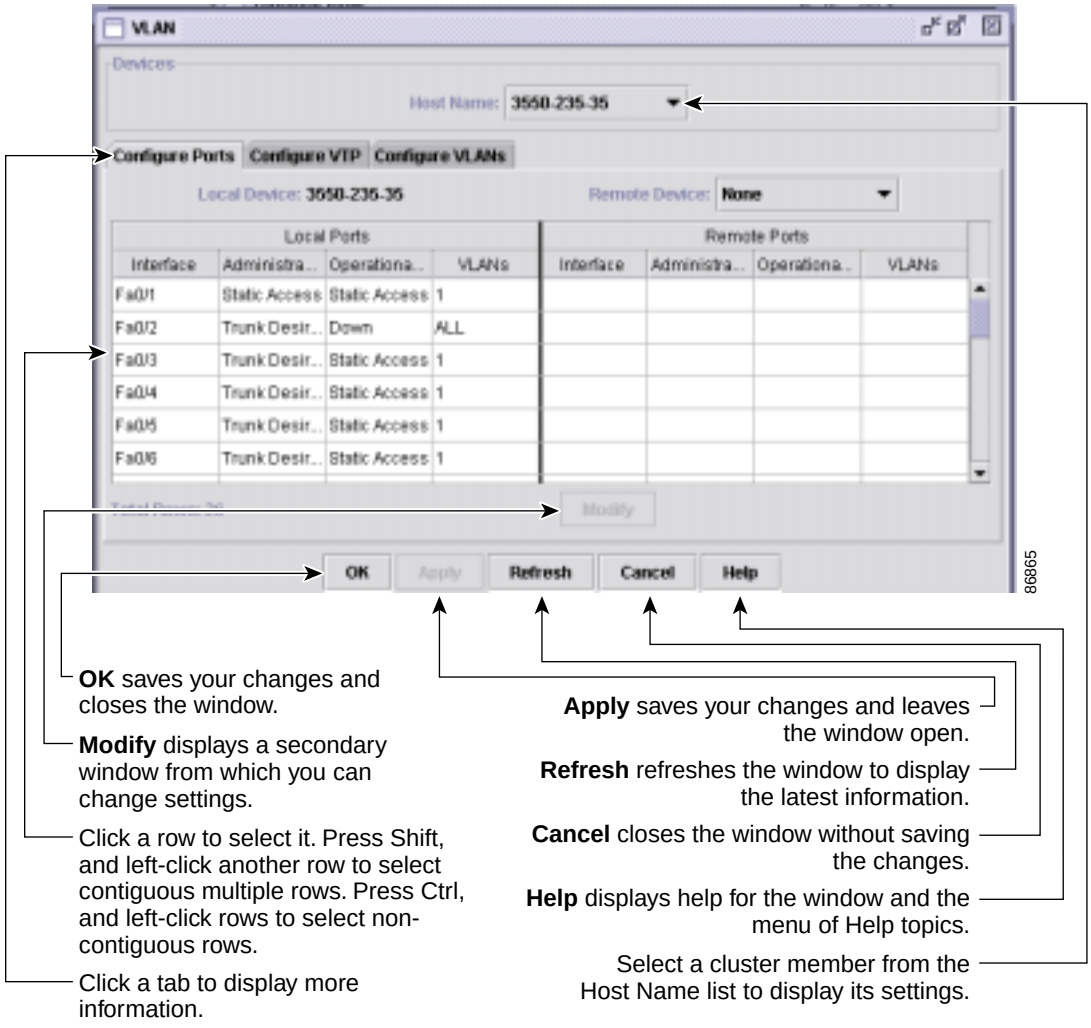
Figure 4-10 Help Contents and Index



CMS Window Components

CMS windows consistently present configuration information. Figure 4-11 shows the components of a typical CMS window.

Figure 4-11 CMS Window Components


VLAN
Devices
Host Name: 3550-235-35
Configure Ports
Configure VTP
Configure VLANs
Local Device: 3550-235-35
Remote Device: None
Local Ports
Remote Ports
Interface
Administra...
Operationa...
VLANs
Fa0/1 Static Access Static Access 1
Fa0/2 Trunk Desir... Down ALL
Fa0/3 Trunk Desir... Static Access 1
Fa0/4 Trunk Desir... Static Access 1
Fa0/5 Trunk Desir... Static Access 1
Fa0/6 Trunk Desir... Static Access 1
Modify
OK
Apply
Refresh
Cancel
Help
86865
OK saves your changes and closes the window.
Modify displays a secondary window from which you can change settings.
Click a row to select it. Press Shift, and left-click another row to select contiguous multiple rows. Press Ctrl, and left-click rows to select non-contiguous rows.
Click a tab to display more information.
Apply saves your changes and leaves the window open.
Refresh refreshes the window to display the latest information.
Cancel closes the window without saving the changes.
Help displays help for the window and the menu of Help topics.
Select a cluster member from the Host Name list to display its settings.

Host Name List

To display or change the configuration of a cluster member, you need to select the specific switch from the Host Name drop-down list. The list appears in the configuration window of each feature and lists only the cluster members that support that feature. For example, the Host Name list on the VLAN window does not include Catalyst 1900 and Catalyst 2820 switches even though they are part of the cluster. Similarly, the Host Name list on the LRE Profiles window only lists the LRE switches in the cluster.

Tabs, Lists, and Tables

Some CMS windows have tabs that present different sets of information. Tabs are arranged like folder headings across the top of the window. Click the tab to display its information.

Listed information can often be changed by selecting an item from a list. To change the information, select one or more items, and click **Modify**. Changing multiple items is limited to those items that apply to at least one of the selections.

Some CMS windows present information in a table format. You can edit the information in these tables.

Note You can resize the width of the columns to display the column headings, or you can hold your cursor over the heading to display a popup description of the column.

Filter Editor

When you click **Filter** in a CMS window that contains a table, the Filter Editor window appears. The column names in the table become the field names in this window. You can enter selection criteria in these field names to filter out table rows that you do not want displayed. For procedures on using the Filter Editor, refer to the online help.

Buttons

These are the most common buttons that you use to change the information in a CMS window:

- OK—Save any changes and close the window. If you made no changes, the window closes. If CMS detects errors in your entry, the window remains open. For more information about error detection, see the "Red Border Around a Field" section on page 4-29.
- Apply—Save any changes made in the window and leave the window open. If you made no changes, the Apply button is disabled.
- Refresh—Update the CMS window with the latest status of the device. Unsaved changes are lost.
- Cancel—Do not save any changes made in the window and close the window.
- Help—Display procedures on performing tasks from the window.
- Modify—Display the secondary window for changing information on the selected item or items. You usually select an item from a list or table and click **Modify**.

Green Border Around a Field or Cell

A green border around a field or table cell means that you made an unsaved change to the field or table cell. Previous information in that field or table cell is displayed in the window status bar. When you save the changes or if you cancel the change, the green border disappears.

Red Border Around a Field

A red border around a field means that you entered invalid data in the field. An error message also displays in the window status bar. When you enter valid data in the field, a green border replaces the red border until you either save or cancel the change.

If there is an error in communicating with the switch or if you make an error while performing an action, a message notifies you about the error.

Accessing CMS

This section assumes the following:

- You know the IP address and password of the command switch or a specific switch. This information is either:
  - Assigned to the switch by following the setup program, as described in the release notes.
  - Changed on the switch by following the information in the "Assigning Switch Information" section on page 5-2 and "Preventing Unauthorized Access to Your Switch" section on page 9-1. Considerations for assigning IP addresses and passwords to a command switch and cluster members are described in the "IP Addresses" section on page 7-16 and the "Passwords" section on page 7-17.
- You know your access privilege level to the switch.
- You have referred to the release notes for system requirements and have followed the procedures for installing the required Java plug-ins and configuring your browser.

Caution Copies of the CMS pages you display are saved in your browser memory cache until you exit the browser session. A password is not required to redisplay these pages, including the Cisco Systems Access page. You can access the command-line interface (CLI) by clicking **Monitor the router - HTML access to the command line interface** from a cached copy of the Cisco Systems Access page. To prevent unauthorized access to CMS and the CLI, exit your browser to end the browser session.

Note If you have configured the Terminal Access Controller Access Control System Plus (TACACS+) or Remote Authentication Dial-In User Service (RADIUS) feature on the switch, you can still access the switch through CMS. For information about how inconsistent authentication configurations in switch clusters can affect access through CMS, see the "TACACS+ and RADIUS" section on page 7-18.

To access CMS, follow these steps:

Step 1 Enter the switch IP address and your privilege level in the browser Location field (Netscape Communicator) or Address field (Microsoft Internet Explorer). For example:

http://10.1.126.45:184/level/14/

where 10.1.126.45 is the switch IP address, 184 is the HTTP port, and level/14 is the privilege level. You do not need to enter the HTTP port if the switch is using HTTP port 80 (the default) or enter the privilege level if you have read-write access to the switch (privilege level is 15). For information about the HTTP port, see the "HTTP Access to CMS" section on page 4-31. For information about privilege levels, see the "Access Modes in CMS" section on page 4-30.

Step 2 When prompted for a username and password, enter only the switch enable password. CMS prompts you a second time for a username and password. Enter only the enable password again.

If you configure a local username and password, make sure you enable it by using the **ip http authentication** global configuration command. Enter your username and password when prompted.

Step 3 Click **Web Console**.

If you access CMS from a standalone or member switch, Device Manager appears. If you access CMS from a command switch, you can display the Front Panel and Topology views.

Access Modes in CMS

CMS provides two levels of access to the configuration options: read-write access and read-only access. Privilege levels 0 to 15 are supported.

- Privilege level 15 provides you with read-write access to CMS.
- Privilege levels 1 to 14 provide you with read-only access to CMS. Any options in the CMS windows, menu bar, toolbar, and popup menus that change the switch or cluster configuration are not shown in read-only mode.
- Privilege level 0 denies access to CMS.

If you do not include a privilege level when you access CMS, the switch verifies if you have privilege-level 15. If you do not, you are denied access to CMS. If you do have privilege-level 15, you are granted read-write access. Therefore, you do not need to include the privilege level if it is 15. Entering zero denies access to CMS. For more information about privilege levels, see the "Preventing Unauthorized Access to Your Switch" section on page 9-1.

If your cluster has these member switches running earlier software releases and if you have read-only access to these member switches, some configuration windows for those switches display incomplete information:

- Catalyst 2900 XL or Catalyst 3500 XL member switches running Release 12.0(5)WC2 or earlier
- Catalyst 2950 member switches running Release 12.0(5)WC2 or earlier
- Catalyst 3550 member switches running Release 12.1(6)EA1 or earlier

For more information about this limitation, refer to the release notes.

These switches do not support read-only mode on CMS:

- Catalyst 1900 and Catalyst 2820
- Catalyst 2900 XL switches with 4-MB CPU DRAM

In read-only mode, these switches appear as unavailable devices and cannot be configured from CMS.

HTTP Access to CMS

CMS uses Hypertext Transfer Protocol (HTTP), which is an in-band form of communication with the switch through any one of its Ethernet ports and that allows switch management from a standard web browser. The default HTTP port is 80.

If you change the HTTP port, you must include the new port number when you enter the IP address in the browser **Location** or **Address** field (for example, http://10.1.126.45:184 where 184 is the new HTTP port number).

Do not disable or otherwise misconfigure the port through which your management station is communicating with the switch. You might want to write down the port number to which you are connected. Changes to the switch IP information should be done with care.

For information about connecting to a switch port, refer to the switch hardware installation guide.

Saving Your Configuration

Note The Save Configuration option is not available if your switch access level is read-only. For more information about the read-only access mode, see the "Access Modes in CMS" section on page 4-30.

Tip As you make cluster configuration changes (except for changes to the Topology view and in the Preferences window), make sure that you periodically save the configuration from the command switch. The configuration is saved on the command and member switches.

The front-panel images and CMS windows always display the running configuration of the switch. When you make a configuration change to a switch or switch cluster, the change becomes part of the running configuration. The change does not automatically become part of the configuration file, which is the startup configuration used each time the switch restarts. If you do not save your changes, they are lost when the switch restarts.

Note Catalyst 1900 and Catalyst 2820 switches automatically save configuration changes to Flash memory as they occur.

Restoring Your Configuration

After you save a switch configuration, you can restore the configuration to one or more switches for these reasons:

- You made an incorrect change to the current running configuration and want to reload a saved configuration.
- You need to reload a switch after a switch failure or power failure.
- You want to copy the configuration of a switch to other switches.

For CMS procedures for restoring a switch configuration, refer to the online help.

CMS Preferences

When you exit from CMS, your CMS preferences are saved to your PC in a file called .cms_properties. You can copy this file to other PCs. The file is stored in a default configuration directory, such as C:\Documents and Settings\username. If you cannot locate the CMS preferences file, select **Start** > **Search** > **For Files or Folders...**, and search for .cms_properties.

Note In previous CMS versions, the preferences were saved in Flash memory when you exited from CMS.

Using Different Versions of CMS

When managing switch clusters through CMS, remember that clusters can have a mix of switch models using different IOS releases and that CMS in earlier IOS releases and on different switch platforms might look and function differently from CMS in this IOS release.

When you select **Device** > **Device Manager** for a cluster member, a new browser session is launched, and the CMS version for that switch is displayed.

Here are examples of how CMS can differ between IOS releases and switch platforms:

- On Catalyst switches running Release 12.0(5)WC2 or earlier or Release 12.1(6)EA1 or earlier, the CMS versions in those software releases might appear similar but are not the same as this release. For example, the Topology view in this release is not the same as the Topology view or Cluster View in those earlier software releases.
- CMS on the Catalyst 1900 and Catalyst 2820 switches is referred to as Switch Manager. Cluster management options are not available on these switches. This is the earliest version of CMS.

Refer to the documentation specific to the switch and its IOS release for descriptions of the CMS version you are using.

Where to Go Next

Before configuring the switch, refer to these places for start-up information:

- Switch release notes on Cisco.com:
  - CMS software requirements
  - Procedures for running the setup program
  - Procedures for browser configuration
  - Procedures for accessing CMS
- Chapter 5, “Assigning the Switch IP Address and Default Gateway”
- Chapter 8, “Administering the Switch”

The rest of this guide provides information about and CLI procedures for the software features supported in this release. For CMS procedures and window descriptions, refer to the online help.

Assigning the Switch IP Address and Default Gateway

This chapter describes how to create the initial switch configuration (for example, assign the switch IP address and default gateway information) by using a variety of automatic and manual methods.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding the Boot Process, page 5-1
- Assigning Switch Information, page 5-2
- Checking and Saving the Running Configuration, page 5-10

Understanding the Boot Process

Before you can assign switch information (IP address, subnet mask, default gateway, secret and Telnet passwords, and so forth), you need to install and power on the switch as described in the hardware installation guide that shipped with your Catalyst 2950 or Catalyst 2955 switch.

The normal boot process involves the operation of the boot loader software, which performs these activities:

- Performs low-level CPU initialization. It initializes the CPU registers, which control where physical memory is mapped, its quantity, its speed, and so forth.
- Performs power-on self-test (POST) for the CPU subsystem. It tests the CPU DRAM and the portion of the Flash device that makes up the Flash file system.
- Initializes the Flash file system on the system board.
- Loads a default operating system software image into memory and boots the switch.

The boot loader provides access to the Flash file system before the operating system is loaded. Normally, the boot loader is used only to load, uncompress, and launch the operating system. After the boot loader gives the operating system control of the CPU, the boot loader is not active until the next system reset or power-on.

The boot loader also provides trap-door access into the system if the operating system has problems serious enough that it cannot be used. The trap-door mechanism provides enough access to the system so that if it is necessary, you can format the Flash file system, reinstall the operating system software image by using the XMODEM Protocol, recover from a lost or forgotten password, and finally restart the operating system. For more information, see the "Recovering from Corrupted Software" section on page 29-2 and the "Recovering from a Lost or Forgotten Password" section on page 29-2.

Before you can assign switch information, make sure you have connected a PC or terminal to the console port, and configured the PC or terminal-emulation software baud rate and character format to match those of the switch console port. For more information, refer to the hardware installation guide that shipped with your switch.

Assigning Switch Information

You can assign IP information through the switch setup program, through a Dynamic Host Configuration Protocol (DHCP) server, or manually.

Use the switch setup program if you are a new user and want to be prompted for specific IP information. With this program, you can also configure a host name and an enable secret password. It gives you the option of assigning a Telnet password (to provide security during remote management) and configuring your switch as a command or member switch of a cluster or as a standalone switch. For more information about the setup program, refer to the release notes on Cisco.com.

Use a DHCP server for centralized control and automatic assignment of IP information once the server is configured.

Note If you are using DHCP, do not respond to any of the questions in the setup program until the switch receives the dynamically-assigned IP address and reads the configuration file.

Use the manual method of configuration if you are an experienced user familiar with the switch configuration steps; otherwise, use the setup program described earlier.

This section contains this configuration information:

- Default Switch Information, page 5-3
- Understanding DHCP-Based Autoconfiguration, page 5-3
- Manually Assigning IP Information, page 5-10

Default Switch Information

Table 5-1 shows the default switch information.

Table 5-1 Default Switch Information

Feature	Default Setting
IP address and subnet mask	No IP address or subnet mask are defined.
Default gateway	No default gateway is defined.
Enable secret password	No password is defined.
Host name	The factory-assigned default host name is *Switch*.
Telnet password	No password is defined.
Cluster command switch functionality	Disabled.
Cluster name	No cluster name is defined.

Understanding DHCP-Based Autoconfiguration

The DHCP provides configuration information to Internet hosts and internetworking devices. This protocol consists of two components: one for delivering configuration parameters from a DHCP server to a device and a mechanism for allocating network addresses to devices. DHCP is built on a client-server model, in which designated DHCP servers allocate network addresses and deliver configuration parameters to dynamically configured devices.

During DHCP-based autoconfiguration, your switch (DHCP client) is automatically configured at startup with IP address information and a configuration file.

With DHCP-based autoconfiguration, no DHCP client-side configuration is needed on your switch. However, you need to configure the DHCP server for various lease options associated with IP addresses. If you are using DHCP to relay the configuration file location on the network, you might also need to configure a Trivial File Transfer Protocol (TFTP) server and a Domain Name System (DNS) server.

The DHCP server can be on the same LAN or on a different LAN than the switch. If the DHCP server is running on a different LAN, you should configure a DHCP relay. A relay device forwards broadcast traffic between two directly connected LANs. A router does not forward broadcast packets, but it forwards packets based on the destination IP address in the received packet.

DHCP-based autoconfiguration replaces the BOOTP client functionality on your switch.

DHCP Client Request Process

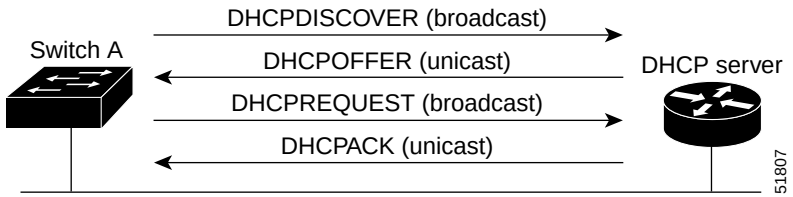
When you boot your switch, the switch automatically requests configuration information from a DHCP server only if a configuration file is not present on the switch.

DHCP autoconfiguration does not occur under these conditions:

- When a configuration file is present and the **service config** global configuration command is disabled on the switch.
- When a configuration file is present and the **service config** global configuration command is enabled on the switch. In this case, the switch broadcasts TFTP requests for the configuration file.

Figure 5-1 shows the sequence of messages that are exchanged between the DHCP client and the DHCP server.

Figure 5-1 DHCP Client and Server Message Exchange



The client, Switch A, broadcasts a DHCPDISCOVER message to locate a DHCP server. The DHCP server offers configuration parameters (such as an IP address, subnet mask, gateway IP address, DNS IP address, a lease for the IP address, and so forth) to the client in a DHCPOFFER unicast message.

In a DHCPREQUEST broadcast message, the client returns a formal request for the offered configuration information to the DHCP server. The formal request is broadcast so that all other DHCP servers that received the DHCPDISCOVER broadcast message from the client can reclaim the IP addresses that they offered to the client.

The DHCP server confirms that the IP address has been allocated to the client by returning a DHCPACK unicast message to the client. With this message, the client and server are bound, and the client uses configuration information received from the server. The amount of information the switch receives depends on how you configure the DHCP server. For more information, see the "Configuring the DHCP Server" section on page 5-5.

If the configuration parameters sent to the client in the DHCPOFFER unicast message are invalid (a configuration error exists), the client returns a DHCPDECLINE broadcast message to the DHCP server.

The DHCP server sends the client a DHCPNAK denial broadcast message, which means that the offered configuration parameters have not been assigned, that an error has occurred during the negotiation of the parameters, or that the client has been slow in responding to the DHCPOFFER message (the DHCP server assigned the parameters to another client).

A DHCP client might receive offers from multiple DHCP or BOOTP servers and can accept any of the offers; however, the client usually accepts the first offer it receives. The offer from the DHCP server is not a guarantee that the IP address is allocated to the client; however, the server usually reserves the address until the client has had a chance to formally request the address. If the switch accepts replies from a BOOTP server and configures itself, the switch broadcasts, instead of unicasts, TFTP requests to obtain the switch configuration file.

Configuring the DHCP Server

You should configure the DHCP server with reserved leases that are bound to each switch by the switch hardware address.

If you want the switch to receive IP address information, you must configure the DHCP server with these lease options:

- IP address of the client (required)
- Subnet mask of the client (required)
- DNS server IP address (optional)
- Router IP address (default gateway address to be used by the switch) (required)

If you want the switch to receive the configuration file from a TFTP server, you must configure the DHCP server with these lease options:

- TFTP server name (required)
- Boot filename (the name of the configuration file that the client needs) (recommended)
- Host name (optional)

Depending on the settings of the DHCP server, the switch can receive IP address information, the configuration file, or both.

If you do not configure the DHCP server with the lease options described earlier, it replies to client requests with only those parameters that are configured. If the IP address and subnet mask are not in the reply, the switch is not configured. If the router IP address or TFTP server name are not found, the switch might send broadcast, instead of unicast, TFTP requests. Unavailability of other lease options does not affect autoconfiguration.

The DHCP server can be on the same LAN or on a different LAN than the switch. If the DHCP server is running on a different LAN, you should configure a DHCP relay. For more information, see the "Configuring the Relay Device" section on page 5-6. If your DHCP server is a Cisco device, refer to the "*IP Addressing and Services*" section in the *Cisco IOS IP and IP Routing Configuration Guide for Release 12.1*.

Configuring the TFTP Server

Based on the DHCP server configuration, the switch attempts to download one or more configuration files from the TFTP server. If you configured the DHCP server to respond to the switch with all the options required for IP connectivity to the TFTP server, and if you configured the DHCP server with a TFTP server name, address, and configuration filename, the switch attempts to download the specified configuration file from the specified TFTP server.

If you did not specify the configuration filename, the TFTP server, or if the configuration file could not be downloaded, the switch attempts to download a configuration file by using various combinations of filenames and TFTP server addresses. The files include the specified configuration filename (if any) and these files: network-config, cisconet.cfg, *hostname*.config, or *hostname*.cfg, where *hostname* is the switch's current hostname. The TFTP server addresses used include the specified TFTP server address (if any) and the broadcast address (255.255.255.255).

For the switch to successfully download a configuration file, the TFTP server must contain one or more configuration files in its base directory. The files can include these files:

- The configuration file named in the DHCP reply (the actual switch configuration file).
- The network-confg or the cisconet.cfg file (known as the default configuration files).
- The router-confg or the ciscortr.cfg file (These files contain commands common to all switches. Normally, if the DHCP and TFTP servers are properly configured, these files are not accessed.)

If you specify the TFTP server name in the DHCP server-lease database, you must also configure the TFTP server name-to-IP-address mapping in the DNS-server database.

If the TFTP server to be used is on a different LAN from the switch, or if it is to be accessed by the switch through the broadcast address (which occurs if the DHCP server response does not contain all the required information described earlier), a relay must be configured to forward the TFTP packets to the TFTP server. For more information, see the "Configuring the Relay Device" section on page 5-6. The preferred solution is to configure the DHCP server with all the required information.

Configuring the DNS

The DHCP server uses the DNS server to resolve the TFTP server name to an IP address. You must configure the TFTP server name-to-IP address map on the DNS server. The TFTP server contains the configuration files for the switch.

You can configure the IP addresses of the DNS servers in the lease database of the DHCP server from where the DHCP replies will retrieve them. You can enter up to two DNS server IP addresses in the lease database.

The DNS server can be on the same or on a different LAN as the switch. If it is on a different LAN, the switch must be able to access it through a router.

Configuring the Relay Device

You must configure a relay device when a switch sends broadcast packets that need to be responded to by a host on a different LAN. Examples of broadcast packets that the switch might send are DHCP, DNS, and in some cases, TFTP packets. You must configure this relay device to forward received broadcast packets on an interface to the destination host.

If the relay device is a Cisco router, enable IP routing (**ip routing** global configuration command), and configure helper addresses by using the **ip helper-address** interface configuration command.

For example, in Figure 5-2, configure the router interfaces as follows:

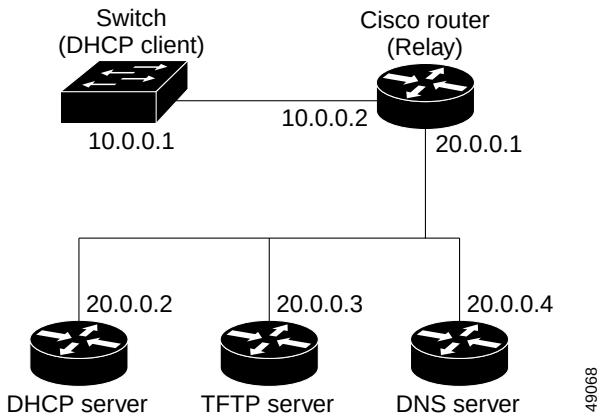
On interface 10.0.0.2:

```
router(config-if)# ip helper-address 20.0.0.2
router(config-if)# ip helper-address 20.0.0.3
router(config-if)# ip helper-address 20.0.0.4
```

On interface 20.0.0.1

```
router(config-if)# ip helper-address 10.0.0.1
```

Figure 5-2 Relay Device Used in Autoconfiguration



Obtaining Configuration Files

Depending on the availability of the IP address and the configuration filename in the DHCP reserved lease, the switch obtains its configuration information in these ways:

- The IP address and the configuration filename is reserved for the switch and provided in the DHCP reply (one-file read method).

  The switch receives its IP address, subnet mask, TFTP server address, and the configuration filename from the DHCP server. The switch sends a unicast message to the TFTP server to retrieve the named configuration file from the base directory of the server, and upon receipt, completes its boot-up process.

- The IP address and the configuration filename is reserved for the switch, but the TFTP server address is not provided in the DHCP reply (one-file read method).

  The switch receives its IP address, subnet mask, and the configuration filename from the DHCP server. The switch sends a broadcast message to a TFTP server to retrieve the named configuration file from the base directory of the server, and upon receipt, completes its boot-up process.

- Only the IP address is reserved for the switch and provided in the DHCP reply. The configuration filename is not provided (two-file read method).

  The switch receives its IP address, subnet mask, and the TFTP server address from the DHCP server. The switch sends a unicast message to the TFTP server to retrieve the network-confg or cisconet.cfg default configuration file. (If the network-confg file cannot be read, the switch reads the cisconet.cfg file.)

  The default configuration file contains the host names-to-IP-address mapping for the switch. The switch fills its host table with the information in the file and obtains its host name. If the host name is not found in the file, the switch uses the host name in the DHCP reply. If the host name is not specified in the DHCP reply, the switch uses the default *Switch* as its host name.

  After obtaining its host name from the default configuration file or the DHCP reply, the switch reads the configuration file that has the same name as its host name (*hostname*-confg or *hostname*.cfg, depending on whether network-confg or cisconet.cfg was read earlier) from the TFTP server. If the cisconet.cfg file is read, the filename of the host is truncated to eight characters.

  If the switch cannot read the network-confg, cisconet.cfg, or the hostname file, it reads the router-confg file. If the switch cannot read the router-confg file, it reads the ciscortr.cfg file.

Note The switch broadcasts TFTP server requests if the TFTP server is not obtained from the DHCP replies, if all attempts to read the configuration file through unicast transmissions fail, or if the TFTP server name cannot be resolved to an IP address.

Example Configuration

Figure 5-3 shows a sample network for retrieving IP information by using DHCP-based autoconfiguration.

Figure 5-3 DHCP-Based Autoconfiguration Network Example

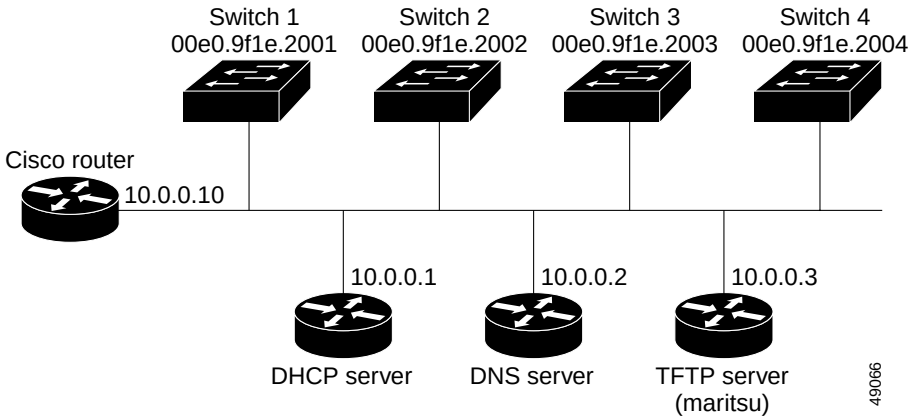


Table 5-2 shows the configuration of the reserved leases on the DHCP server.

Table 5-2 DHCP Server Configuration

	Switch-1	Switch-2	Switch-3	Switch-4
Binding key (hardware address)	00e0.9f1e.2001	00e0.9f1e.2002	00e0.9f1e.2003	00e0.9f1e.2004
IP address	10.0.0.21	10.0.0.22	10.0.0.23	10.0.0.24
Subnet mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Router address	10.0.0.10	10.0.0.10	10.0.0.10	10.0.0.10
DNS server address	10.0.0.2	10.0.0.2	10.0.0.2	10.0.0.2
TFTP server name	maritsu or 10.0.0.3	maritsu or 10.0.0.3	maritsu or 10.0.0.3	maritsu or 10.0.0.3
Boot filename (configuration file) (optional)	switch1-confg	switch2-confg	switch3-confg	switch4-confg
Host name (optional)	switch1	switch2	switch3	switch4

DNS Server Configuration

The DNS server maps the TFTP server name *maritsu* to IP address 10.0.0.3.

TFTP Server Configuration (on UNIX)

The TFTP server base directory is set to /tftpserver/work/. This directory contains the network-confg file used in the two-file read method. This file contains the host name to be assigned to the switch based on its IP address. The base directory also contains a configuration file for each switch (*switch1-confg*, *switch2-confg*, and so forth) as shown in this display:

```
prompt> cd /tftpserver/work/
prompt> ls
network-confg
switch1-confg
switch2-confg
switch3-confg
switch4-confg
prompt> cat network-confg
ip host switch1 10.0.0.21
ip host switch2 10.0.0.22
ip host switch3 10.0.0.23
ip host switch4 10.0.0.24
```

DHCP Client Configuration

No configuration file is present on Switch 1 through Switch 4.

Configuration Explanation

In Figure 5-3, Switch 1 reads its configuration file as follows:

- It obtains its IP address 10.0.0.21 from the DHCP server.
- If no configuration filename is given in the DHCP server reply, Switch 1 reads the network-confg file from the base directory of the TFTP server.
- It adds the contents of the network-confg file to its host table.
- It reads its host table by indexing its IP address 10.0.0.21 to its host name (switch1).
- It reads the configuration file that corresponds to its host name; for example, it reads *switch1-confg* from the TFTP server.

Switches 2 through 4 retrieve their configuration files and IP addresses in the same way.

Manually Assigning IP Information

Beginning in privileged EXEC mode, follow these steps to manually assign IP information to multiple switched virtual interfaces (SVIs) or ports:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface vlan** *vlan-id*	Enter interface configuration mode, and enter the VLAN to which the IP information is assigned. The range is 1 to 4094 when the enhanced software image is installed and 1 to 1001 when the standard software image is installed.
Step 3	**ip address** *ip-address subnet-mask*	Enter the IP address and subnet mask.
Step 4	**exit**	Return to global configuration mode.
Step 5	**ip default-gateway** *ip-address*	Enter the IP address of the next-hop router interface that is directly connected to the switch where a default gateway is being configured. The default gateway receives IP packets with unresolved destination IP addresses from the switch. Once the default gateway is configured, the switch has connectivity to the remote networks with which a host needs to communicate. **Note** When your switch is configured to route with IP, it does not need to have a default gateway set.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the switch IP address, use the **no ip address** interface configuration command. If you are removing the address through a Telnet session, your connection to the switch will be lost. To remove the default gateway address, use the **no ip default-gateway** global configuration command.

For information on setting the switch system name, protecting access to privileged EXEC commands, and setting time and calendar services, see Chapter 8, “Administering the Switch.”

Checking and Saving the Running Configuration

You can check the configuration settings you entered or changes you made by entering this privileged EXEC command:

```
Switch# show running-config

Building configuration...

Current configuration : 2081 bytes
!
version 12.1
no service pad
service timestamps debug uptime
service timestamps log datetime
no service password-encryption
service sequence-numbers
```

```
!
hostname Switch
!
enable secret 5 $1$ej9.$DMUvAUnZOAmvmgqBEzIxE0
!
ip subnet-zero
!
vlan 3020
cluster enable Test 0
cluster member 1 mac-address 0030.9439.0900
cluster member 2 mac-address 0001.425b.4d80
!
spanning-tree extend system-id
!
!
interface Port-channel1
no ip address
!
interface FastEthernet0/1
 switchport mode access
 switchport voice vlan 400
 switchport priority extend cos 5
 no ip address
 spanning-tree portfast trunk
!
interface FastEthernet0/2
 switchport mode access
 no ip address
!
...
interface FastEthernet0/8
 switchport mode access
 switchport voice vlan 350
 no ip address
 spanning-tree portfast trunk
!
interface FastEthernet0/9
 switchport mode access
 no ip address
 shutdown
!
interface FastEthernet0/10
 switchport trunk native vlan 2
 no ip address
 speed 100
!
interface FastEthernet0/11
 switchport voice vlan 4046
 no ip address
 shutdown
 spanning-tree portfast trunk
!
interface FastEthernet0/12
 switchport mode access
 switchport voice vlan 4011
 no ip address
 shutdown
 spanning-tree portfast trunk
!
interface GigabitEthernet0/1
 no ip address
 shutdown
!
```

```
interface GigabitEthernet0/2
 no ip address
 shutdown
!
interface Vlan1
 ip address 172.20.139.133 255.255.255.224
 no ip route-cache
!
ip default-gateway 172.20.139.129
ip http server
!
ip access-list extended CMP-NAT-ACL
!
snmp-server engineID local 800000090300000 5742809C1
snmp-server community public RO
snmp-server community public@es0 RO
snmp-server enable traps MAC-Notification
!
line con 0
 password letmein
line vty 0 4
 password letmein
 login
line vty 5 15
 password letmein
 login
!
end
```

To store the configuration or changes you have made to your startup configuration in Flash memory, enter this privileged EXEC command:

```
Switch# copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
```

This command saves the configuration settings that you made. If you fail to do this, your configuration will be lost the next time you reload the system. To display information stored in the NVRAM section of Flash memory, use the **show startup-config** or **more startup-config** privileged EXEC command.

Configuring IE2100 CNS Agents

This chapter describes how to configure the Intelligence Engine 2100 (IE2100) Series Cisco Networking Services (CNS) embedded agents on your Catalyst 2950 or Catalyst 2955 switch. To use the feature described in this chapter, you must have the enhanced software image (EI) installed on your switch.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco Intelligence Engine 2100 Series Configuration Registrar Manual*, and select **Cisco IOS Software Release 12.2 > New Feature Documentation > 12.2(2)T** on Cisco.com.

This chapter consists of these sections:

- Understanding IE2100 Series Configuration Registrar Software, page 6-1
- Understanding CNS Embedded Agents, page 6-5
- Configuring CNS Embedded Agents, page 6-6
- Displaying CNS Configuration, page 6-13

Understanding IE2100 Series Configuration Registrar Software

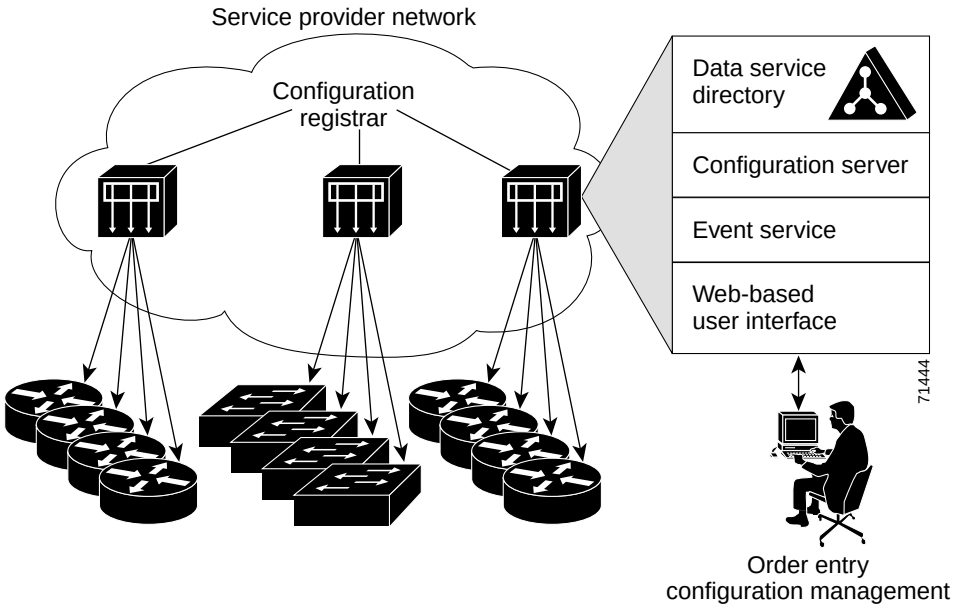
The IE2100 Series Configuration Registrar is a network management device that acts as a configuration service for automating the deployment and management of network devices and services (see Figure 6-1). Each Configuration Registrar manages a group of Cisco IOS devices (switches and routers) and the services that they deliver, storing their configurations and delivering them as needed. The Configuration Registrar automates initial configurations and configuration updates by generating device-specific configuration changes, sending them to the device, executing the configuration change, and logging the results.

The Configuration Registrar supports standalone and server modes and has these CNS components:

- Configuration service (web server, file manager, and namespace mapping server)
- Event service (event gateway)
- Data service directory (data models and schema)

In standalone mode, the Configuration Registrar supports an embedded CNS Directory Service. In this mode, no external directory or other data store is required. In server mode, the Configuration Registrar supports the use of a user-defined external directory.

Figure 6-1 Configuration Registrar Architectural Overview



These sections contain this conceptual information:

- CNS Configuration Service, page 6-2
- CNS Event Service, page 6-3
- What You Should Know About ConfigID, DeviceID, and Host Name, page 6-3

CNS Configuration Service

The CNS Configuration Service is the core component of the Configuration Registrar. It consists of a configuration server that works with CNS configuration agents located on the switch. The CNS Configuration Service delivers device and service configurations to the switch for initial configuration and mass reconfiguration by logical groups. Switches receive their initial configuration from the CNS Configuration Service when they start up on the network for the first time.

The CNS Configuration Service uses the CNS Event Service to send and receive configuration change events and to send success and failure notifications.

The configuration server is a web server that uses configuration templates and the device-specific configuration information stored in the embedded (standalone mode) or remote (server mode) directory.

Configuration templates are text files containing static configuration information in the form of CLI commands. In the templates, variables are specified using lightweight directory access protocol (LDAP) URLs that reference the device-specific configuration information stored in a directory.

The configuration agent can perform a syntax check on received configuration files and publish events to indicate the success or failure of the syntax check. The configuration agent can either apply configurations immediately or delay the application until receipt of a synchronization event from the configuration server.

CNS Event Service

The Configuration Registrar uses the CNS Event Service for receipt and generation of configuration events. The CNS event agent resides on the switch and facilitates the communication between the switch and the event gateway on the Configuration Registrar.

The CNS Event Service is a highly-scalable publish-and-subscribe communication method. The CNS Event Service uses subject-based addressing to send messages to their destinations. Subject-based addressing conventions define a simple, uniform namespace for messages and their destinations.

NameSpace Mapper

The Configuration Registrar includes the NameSpace Mapper (NSM) that provides a lookup service for managing logical groups of devices based on application, device ID or group ID, and event.

Cisco IOS devices recognize only event subject-names that match those configured in Cisco IOS software; for example, cisco.cns.config.load. You can use the namespace mapping service to designate events by using any desired naming convention. When you have populated your data store with your subject names, NSM resolves your event subject-name strings to those known by IOS.

For a subscriber, when given a unique device ID and event, the namespace mapping service returns a set of events to which to subscribe. Similarly, for a publisher, when given a unique group ID, device ID, and event, the mapping service returns a set of events on which to publish.

What You Should Know About ConfigID, DeviceID, and Host Name

The Configuration Registrar assumes that a unique identifier is associated with each configured switch. This unique identifier can take on multiple synonyms, where each synonym is unique within a particular namespace. The event service uses namespace content for subject-based addressing of messages.

The Configuration Registrar intersects two namespaces, one for the event bus and the other for the configuration server. Within the scope of the configuration server namespace, the term configID is the unique identifier for a device. Within the scope of the event bus namespace, the term deviceID is the CNS unique identifier for a device.

Because the Configuration Registrar uses both the event bus and the configuration server to provide configurations to devices, you must define both configID and deviceID for each configured switch.

Within the scope of a single instance of the configuration server, no two configured switches can share the same value for configID. Within the scope of a single instance of the event bus, no two configured switches can share the same value for deviceID.

ConfigID

Each configured switch has a unique configID, which serves as the key into the Configuration Registrar directory for the corresponding set of switch CLI attributes. The configID defined on the switch must match the configID for the corresponding switch definition on the Configuration Registrar.

The configID is fixed at boot time and cannot be changed until reboot, even when the switch host name is reconfigured.

DeviceID

Each configured switch participating on the event bus has a unique deviceID, which is analogous to the switch source address so that the switch can be targeted as a specific destination on the bus. All switches configured with the **cns config partial** global configuration command must access the event bus. Therefore, the deviceID, as originated on the switch, must match the deviceID of the corresponding switch definition in the Configuration Registrar.

The origin of the deviceID is defined by the Cisco IOS host name of the switch. However, the deviceID variable and its usage reside within the event gateway, which is adjacent to the switch.

The logical Cisco IOS termination point on the event bus is embedded in the event gateway, which in turn functions as a proxy on behalf of the switch. The event gateway represents the switch and its corresponding deviceID to the event bus.

The switch declares its host name to the event gateway immediately after the successful connection to the event gateway. The event gateway couples the deviceID value to the Cisco IOS host name each time this connection is established. The event gateway caches this deviceID value for the duration of its connection to the switch.

Host Name and DeviceID

The deviceID is fixed at the time of the connection to the event gateway and does not change even when the switch host name is reconfigured.

When changing the switch host name on the switch, the only way to refresh the deviceID is to break the connection between the switch and the event gateway. Enter the **no cns event** global configuration command followed by the **cns event** global configuration command.

When the connection is re-established, the switch sends its modified host name to the event gateway. The event gateway redefines the deviceID to the new value.

Caution When using the Configuration Registrar user interface, you must first set the deviceID field to the host name value that the switch acquires *after*–not *before*–you use the **cns config initial** global configuration command at the switch. Otherwise, subsequent **cns config partial** global configuration command operations malfunction.

Using Host Name, DeviceID, and ConfigID

In standalone mode, when a host name value is set for a switch, the configuration server uses the host name as the deviceID when an event is sent on host name. If the host name has not been set, the event is sent on the cn=<*value*> of the device.

In server mode, the host name is not used. In this mode, the unique deviceID attribute is always used for sending an event on the bus. If this attribute is not set, you cannot update the switch.

These and other associated attributes (tag value pairs) are set when you run **Setup** on the Configuration Registrar.

Note For more information about running the setup program on the Configuration Registrar, refer to the *Cisco Intelligence Engine 2100 Series Configuration Registrar Manual*.

Understanding CNS Embedded Agents

The CNS event agent feature allows the switch to publish and subscribe to events on the event bus and works with the CNS configuration agent. The CNS configuration agent feature supports the switch by providing:

- Initial configurations
- Incremental (partial) configurations
- Synchronized configuration updates

Initial Configuration

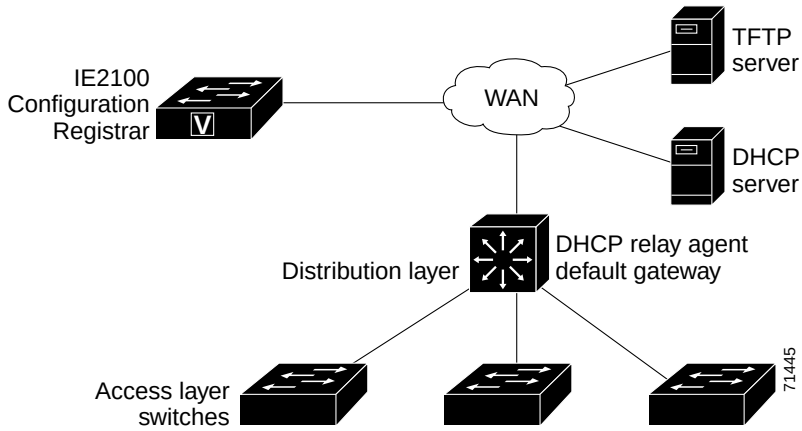
When the switch first comes up, it attempts to get an IP address by broadcasting a Dynamic Host Configuration Protocol (DHCP) request on the network. Assuming there is no DHCP server on the subnet, the distribution switch acts as a DHCP relay agent and forwards the request to the DHCP server. Upon receiving the request, the DHCP server assigns an IP address to the new switch and includes the Trivial File Transfer Protocol (TFTP) server IP address, the path to the bootstrap configuration file, and the default gateway IP address in a unicast reply to the DHCP relay agent. The DHCP relay agent forwards the reply to the switch.

The switch automatically configures the assigned IP address on interface VLAN 1 (the default) and downloads the bootstrap configuration file from the TFTP server. Upon successful download of the bootstrap configuration file, the switch loads the file in its running configuration.

The embedded CNS agents initiate communication with the IE2100 Configuration Registrar by using the appropriate configID and eventID. The Configuration Registrar maps the configID to a template and downloads the full configuration file to the switch.

Figure 6-2 shows a sample network configuration for retrieving the initial bootstrap configuration file by using DHCP-based autoconfiguration.

Figure 6-2 Initial Configuration Overview



Incremental (Partial) Configuration

After the network is running, new services can be added by using the CNS configuration agent. Incremental (partial) configurations can be sent to the switch. The actual configuration can be sent as an event payload by way of the event gateway (push operation) or as a signal event that triggers the switch to initiate a pull operation.

The switch can check the syntax of the configuration before applying it. If the syntax is correct, the switch applies the incremental configuration and publishes an event that signals success to the configuration server. If the switch does not apply the incremental configuration, it publishes an event showing an error status. When the switch has applied the incremental configuration, it can write it to nonvolatile RAM (NVRAM) or wait until signaled to do so.

Synchronized Configuration

When the switch receives a configuration, it can defer application of the configuration upon receipt of a write-signal event. The write-signal event tells the switch not to save the updated configuration into its NVRAM. The switch uses the updated configuration as its running configuration. This ensures that the switch configuration is synchronized with other network activities before saving the configuration in NVRAM for use at the next reboot.

Configuring CNS Embedded Agents

The CNS agents embedded in the switch IOS software allow the switch to be connected and automatically configured as described in the "Enabling Automated CNS Configuration" section on page 6-6. If you want to change the configuration or install a custom configuration, see these sections for instructions:

- Enabling the CNS Event Agent, page 6-8
- Enabling the CNS Configuration Agent, page 6-9

Enabling Automated CNS Configuration

To enable automated CNS configuration of the switch, you must first complete the prerequisites in Table 6-1. When you complet them, power on the switch. At the **setup** prompt, do nothing: The switch begins the initial configuration as described in the "Initial Configuration" section on page 6-5. When the full configuration file is loaded on your switch, you need to do nothing else.

Table 6-1 Prerequisites for Enabling Automatic Configuration

Device	Required Configuration
Access switch	Factory default (no configuration file)
Distribution switch	• IP helper address • Enable DHCP relay agent • IP routing (if used as default gateway)

Table 6-1 Prerequisites for Enabling Automatic Configuration (continued)

Device	Required Configuration
DHCP server	• IP address assignment • TFTP server IP address • Path to bootstrap configuration file on the TFTP server • Default gateway IP address
TFTP server	• Create a bootstrap configuration file that includes the CNS configuration commands that enable the switch to communicate with the IE2100 Configuration Registrar. • Configure the switch to use either the switch MAC address or the serial number (instead of the default host name) to generate the configID and eventID. • Configure the CNS event agent to push the configuration file to the switch.
IE2100 Configuration Registrar	Create one or more templates for each type of device, and map the configID of the device to the template.

Note For more information about running the setup program and creating templates on the Configuration Registrar, refer to the *Cisco Intelligence Engine 2100 Series Configuration Registrar Manual*.

Enabling the CNS Event Agent

Note You must enable the CNS event agent on the switch before you enable the CNS configuration agent.

Beginning in privileged EXEC mode, follow these steps to enable the CNS event agent on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**cns event** {*ip-address* | *hostname*} [*port-number*] [**backup**] [**init-retry** *retry-count*] [**keepalive** *seconds retry-count*] [**source** *ip-address*]	Enable the event agent, and enter the gateway parameters. • For {*ip-address* | *hostname*}, enter either the IP address or the host name of the event gateway. • (Optional) For *port number*, enter the port number for the event gateway. The default port number is 11011. • (Optional) Enter **backup** to show that this is the backup gateway. (If omitted, this is the primary gateway.) • (Optional) For **init-retry** *retry-count*, enter the number of initial retries before switching to backup. The default is 3. • (Optional) For **keepalive** *seconds*, enter how often the switch sends keepalive messages. For *retry-count*, enter the number of unanswered keepalive messages that the switch sends before the connection is terminated. The default for each is 0. • (Optional) For **source** *ip-address*, enter the source IP address of this device. **Note** Though visible in the command-line help string, the **encrypt** and **force-fmt1** keywords are not supported.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show cns event connections**	Verify information about the event agent.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable the CNS event agent, use the **no cns event** {*ip-address* | *hostname*} global configuration command.

This example shows how to enable the CNS event agent, set the IP address gateway to 10.180.1.27, set 120 seconds as the keepalive interval, and set 10 as the retry count.

```
Switch(config)# cns event 10.180.1.27 keepalive 120 10
```

Enabling the CNS Configuration Agent

After enabling the CNS event agent, start the CNS configuration agent on the switch. You can enable the configuration agent with these commands:

- the **cns config initial** global configuration command enables the configuration agent and initiates an initial configuration on the switch.
- the **cns config partial** global configuration command enables the configuration agent and initiates a partial configuration on the switch. You can then remotely send incremental configurations to the switch from the Configuration Registrar.

Enabling an Initial Configuration

Beginning in privileged EXEC mode, follow these steps to enable the CNS configuration agent and initiate an initial configuration on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**cns config connect-intf** *interface-prefix* [**ping-interval** *seconds*] [**retries** *num*]	Enter the connect-interface-config submode, and specify the interface for connecting to the Configuration Registrar. • Enter the *interface-prefix* for the connecting interface. You must specify the interface type but need not specify the interface number. • (Optional) For **ping-interval** *seconds*, enter the interval between successive ping attempts. The range is 1 to 30 seconds. The default is 10 seconds. • (Optional) For **retries** *num*, enter the number of ping retries. The range is 1 to 30. The default is 5.

	Command	Purpose
Step 3	**config-cli** or **line-cli**	Enter **config-cli** to connect to the Configuration Registrar through the interface defined in **cns config connect-intf**. Enter **line-cli** to connect to the Registrar through modem dialup lines. **Note** The **config-cli** interface configuration command accepts the special directive character **&** that acts as a placeholder for the interface name. When the configuration is applied, the **&** is replaced with the interface name. For example, to connect through FastEthernet0/0, the command **`config-cli ip route 0.0.0.0 0.0.0.0 &`** generates the command **`ip route 0.0.0.0 0.0.0.0 FastEthernet0/0`**.
Step 4	**exit**	Return to global configuration mode.
Step 5	**hostname** *name*	Enter the host name for the switch.
Step 6	**ip route** *network-number*	Establish a static route to the Configuration Registrar whose IP address is *network-number.*
Step 7	**cns id** *interface num* {**dns-reverse** | **ipaddress** | **mac-address**} [**event**] or **cns id** {**hardware-serial** | **hostname** | **string** *string*} [**event**]	Set the unique eventID or configID used by the Configuration Registrar. • For *interface num*, enter the type of interface–for example, Ethernet, Group-Async, Loopback, or Virtual-Template. This setting specifies from which interface the IP or MAC address should be retrieved to define the unique ID. • For {**dns-reverse** | **ipaddress** | **mac-address**} enter **dns-reverse** to retrieve the host name and assign it as the unique ID, enter **ipaddress** to use the IP address, or enter **mac-address** to use the MAC address as the unique ID. • (Optional) Enter **event** to set the ID to be the event-id value used to identify the switch. • For {**hardware-serial** | **hostname**| **string** *string*}, enter **hardware-serial** to set the switch serial number as the unique ID, enter **hostname** (the default) to select the switch host name as the unique ID, or enter an arbitrary text string for **string** *string* as the unique ID.

	Command	Purpose
Step 8	**cns config initial** {*ip-address* | *hostname*} [*port-number*] [**event**] [**no-persist**] [**page** *page*] [**source** *ip-address*] [**syntax-check**]	Enable the configuration agent, and initiate an initial configuration. • For {*ip-address* | *hostname*}, enter the IP address or the host name of the configuration server. • (Optional) For *port-number*, enter the port number of the configuration server. The default port number is 80. • (Optional) Enable **event** for configuration success, failure, or warning messages when the configuration is finished. • (Optional) Enable **no-persist** to suppress the automatic writing to NVRAM of the configuration pulled as a result of entering the **cns config initial** global configuration command. If the **no-persist** keyword is not entered, using the **cns config initial** command causes the resultant configuration to be automatically written to NVRAM. • (Optional) For **page** *page*, enter the web page of the initial configuration. The default is /Config/config/asp. • (Optional) Enter **source** *ip-address* to use for source IP address. • (Optional) Enable **syntax-check** to check the syntax when this parameter is entered. **Note** Though visible in the command-line help string, the **encrypt** keyword is not supported.
Step 9	**end**	Return to privileged EXEC mode.
Step 10	**show cns config connections**	Verify information about the configuration agent.
Step 11	**show running-config**	Verify your entries.

To disable the CNS configuration agent, use the **no cns config initial** {*ip-address* | *hostname*} global configuration command.

This example shows how to configure an initial configuration on a remote switch. The switch host name is the unique ID. The CNS Configuration Registrar IP address is 172.28.129.22.

```
Switch(config)# cns config connect-intf serial ping-interval 1 retries 1
Switch(config-cns-conn-if)# config-cli ip address negotiated
Switch(config-cns-conn-if)# config-cli encapsulation ppp
Switch(config-cns-conn-if)# config-cli ip directed-broadcast
Switch(config-cns-conn-if)# config-cli no keepalive
Switch(config-cns-conn-if)# config-cli no shutdown
Switch(config-cns-conn-if)# exit
Switch(config)# hostname RemoteSwitch
RemoteSwitch(config)# ip route 10.1.1.1 255.255.255.255 11.11.11.1
RemoteSwitch(config)# cns id Ethernet 0 ipaddress
RemoteSwitch(config)# cns config initial 10.1.1.1 no-persist
```

Enabling a Partial Configuration

Beginning in privileged EXEC mode, follow these steps to enable the CNS configuration agent and to initiate a partial configuration on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**cns config partial** {*ip-address* | *hostname*} [*port-number*] [**source** *ip-address*]	Enable the configuration agent, and initiate a partial configuration. • For {*ip-address* | *hostname*}, enter the IP address or the host name of the configuration server. • (Optional) For *port-number*, enter the port number of the configuration server. The default port number is 80. • (Optional) Enter **source** *ip-address* to use for the source IP address. **Note** Though visible in the command-line help string, the **encrypt** keyword is not supported.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show cns config stats** or **show cns config outstanding**	Verify information about the configuration agent.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable the CNS configuration agent, use the **no cns config partial** {*ip-address* | *hostname*} global configuration command. To cancel a partial configuration, use the **cns config cancel** privileged EXEC command.

Displaying CNS Configuration

You can use the privileged EXEC commands in Table 6-2 to display CNS Configuration information.

Table 6-2 Displaying CNS Configuration

Command	Purpose
show cns config connections	Displays the status of the CNS configuration agent connections.
show cns config outstanding	Displays information about incremental (partial) CNS configurations that have started but are not yet completed.
show cns config stats	Displays statistics about the CNS configuration agent.
show cns event connections	Displays the status of the CNS event agent connections.
show cns event stats	Displays statistics about the CNS event agent.
show cns event subject	Displays a list of event agent subjects that are subscribed to by applications.

Clustering Switches

This chapter provides these topics to help you get started with switch clustering:

- Understanding Switch Clusters, page 7-2
- Planning a Switch Cluster, page 7-5
- Creating a Switch Cluster, page 7-20
- Using the CLI to Manage Switch Clusters, page 7-27
- Using SNMP to Manage Switch Clusters, page 7-28

Configuring switch clusters is more easily done from the Cluster Management Suite (CMS) web-based interface than through the command-line interface (CLI). Therefore, information in this chapter focuses on using CMS to create a cluster. See Chapter 4, "Getting Started with CMS," for additional information about switch clusters and the clustering options. For complete procedures about using CMS to configure switch clusters, refer to the online help.

For the CLI cluster commands, refer to the switch command reference.

Refer to the release notes for the list of Catalyst switches eligible for switch clustering, including which ones can be command switches and which ones can only be member switches, and for the required software versions and browser and Java plug-in configurations.

Note This chapter focuses on Catalyst 2950 or Catalyst 2955 switch clusters. It also includes guidelines and limitations for clusters mixed with other cluster-capable Catalyst switches, but it does not provide complete descriptions of the cluster features for these other switches. For complete cluster information for a specific Catalyst platform, refer to the software configuration guide for that switch.

Understanding Switch Clusters

A switch cluster is a group of connected Catalyst switches that are managed as a single entity. In a switch cluster, 1 switch must be the *command switch* and up to 15 switches can be *member switches*. The total number of switches in a cluster cannot exceed 16 switches. The command switch is the single point of access used to configure, manage, and monitor the member switches. Cluster members can belong to only one cluster at a time.

The benefits of clustering switches include:

- Management of Catalyst switches regardless of their interconnection media and their physical locations. The switches can be in the same location, or they can be distributed across a Layer 2 or Layer 3 (if your cluster is using a Catalyst 3550 multilayer switch as a Layer 3 router between the Layer 2 switches in the cluster) network.

  Cluster members are connected to the command switch according to the connectivity guidelines described in the "Automatic Discovery of Cluster Candidates and Members" section on page 7-6.
- Command-switch redundancy if a command switch fails. One or more switches can be designated as *standby command switches* to avoid loss of contact with cluster members. A *cluster standby group* is a group of standby command switches.
- Management of a variety of Catalyst switches through a single IP address. This conserves on IP addresses, especially if you have a limited number of them. All communication with the switch cluster is through the command switch IP address.

For other clustering benefits, see the "Advantages of Using CMS and Clustering Switches" section on page 1-8.

Refer to the release notes for the list of Catalyst switches eligible for switch clustering, including which ones can be command switches and which ones can only be member switches, and the required software versions.

These sections describe:

- Command Switch Characteristics, page 7-3
- Standby Command Switch Characteristics, page 7-3
- Candidate Switch and Member Switch Characteristics, page 7-5

Command Switch Characteristics

A Catalyst 2950 or Catalyst 2955 command switch must meet these requirements:

- It is running Release 12.0(5.2)WC(1) or later.
- It has an IP address.
- It has Cisco Discovery Protocol (CDP) version 2 enabled (the default).
- It is not a command or member switch of another cluster.
- If the Catalyst 2955 command switch is running Release 12.1(12c)EA1 or later, it is connected to the standby command switches through the managmement VLAN and to the member switches through a common VLAN.
- If the Catalyst 2950 command switch is running Release 12.1(9)EA1 or later, it is connected to the standby command switches through the managmement VLAN and to the member switches through a common VLAN.
- If the Catalyst 2950 command switch is running a release earlier than Release 12.1(9)EA1, it is connected to the standby command switches and member switches through its management VLAN.

Note The CMP-NAT-ACL access list is created when a device is configured as the command switch. Configuring any other access list on the switch can restrict access to it and affect the discovery of member and candidate switches.

Note

- We strongly recommend that the highest-end, command-capable switch in the cluster be the command switch:
  - If your switch cluster has a Catalyst 3550 switch, that switch should be the command switch.
  - If your switch cluster has Catalyst 2900 XL, Catalyst 2950, Catalyst 2955, and Catalyst 3500 XL switches, the Catalyst 2950 or the Catalyst 2955 should be the command switch.
  - If your switch cluster has Catalyst 1900, Catalyst 2820, Catalyst 2900 XL, and Catalyst 3500 XL switches, either the Catalyst 2900 XL or Catalyst 3500 XL should be the command switch.

Standby Command Switch Characteristics

A Catalyst 2950 or Catalyst 2955 standby command switch must meet these requirements:

- It is running Release 12.0(5.2)WC(1) or later.
- It has an IP address.
- It has CDP version 2 enabled.
- If the Catalyst 2955 standby command switch is running Release 12.1(12c)EA1 or later, it is connected to other standby switches through its managment VLAN and to all member switches through a common VLAN.

- If the Catalyst 2950 standby command switch is running Release 12.1(9)EA1 or later, it is connected to other standby switches through its managment VLAN and to all member switches through a common VLAN.
- If the Catalyst 2950 standby command switch is running a release earlier than Release 12.1(9)EA1, it is connected to the command switch and to other standby command switches and member switches through its management VLAN.

Note Catalyst 2950 command switches running Release 12.1(9)EA1 or later can connect to standby command switches in the management VLAN. Catalyst 2955 command switches running Release 12.1(12c)EA1 or later can connect to standby command switches in the management VLAN.

- It is redundantly connected to the cluster so that connectivity to member switches is maintained.
- It is not a command or member switch of another cluster.

Note

- Standby command switches must meet these requirements:
  - When the command switch is a Catalyst 3550 switch, all standby command switches must be Catalyst 3550 switches.
  - When the command switch is a Catalyst 2955 switch running Release 12.1(12c)EA1 or later, all standby command switches must be Catalyst 2955 switches running Release 12.1(12c)EA1 or later.
  - When the command switch is a Catalyst 2950 switch running Release 12.1(9)EA1 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(9)EA1 or later.
  - When the command switch is a Catalyst 2950 switch running Release 12.1(6)EA2 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(6)EA2 or later.
  - When the command switch is running Release 12.0(5)WC2 or earlier, the standby command switches can be these switches: Catalyst 2900 XL, Catalyst 2950, and Catalyst 3500 XL switches.
- We strongly recommend that the command switch and standby command switches are of the same switch platform.
  - If you have a Catalyst 3550 command switch, the standby command switches should be Catalyst 3550 switches.
  - If you have a Catalyst 2955 command switch, the standby command switches should be Catalyst 2955 switches.
  - If you have a Catalyst 2950 command switch, the standby command switches should be Catalyst 2950 switches.
  - If you have a Catalyst 2900 XL or Catalyst 3500 XL command switch, the standby command switches should be Catalyst 2900 XL and Catalyst 3500 XL switches.

Candidate Switch and Member Switch Characteristics

Candidate switches are cluster-capable switches that have not yet been added to a cluster. Member switches are switches that have actually been added to a switch cluster. Although not required, a candidate or member switch can have its own IP address and password (for related considerations, see the "IP Addresses" section on page 7-16 and "Passwords" section on page 7-17).

To join a cluster, a candidate switch must meet these requirements:

- It is running cluster-capable software.
- It has CDP version 2 enabled.
- It is not a command or member switch of another cluster.
- If the Catalyst 2955 member or candidate switch is running Release 12.1(12c)EA1 or later, it is connected to the command switch through at least one common VLAN.
- If the Catalyst 2950 member or candidate switch is running Release 12.1(9)EA1 or later, it is connected to the command switch through at least one common VLAN.
- If the Catalyst 2950 member or candidate switch is running a release earlier than Release 12.1(9)EA1, it is connected to the command switch through the command-switch management VLAN.

Note Catalyst 2950 standby command switches running Release 12.1(9)EA1 or later can connect to candidate and member switches in VLANs different from their management VLANs. Catalyst 2955 standby command switches running Release 12.1(12c)EA1 or later can connect to candidate and member switches in VLANs different from their management VLANs.

Planning a Switch Cluster

Anticipating conflicts and compatibility issues is a high priority when you manage several switches through a cluster. This section describes these guidelines, requirements, and caveats that you should understand before you create the cluster:

- Automatic Discovery of Cluster Candidates and Members, page 7-6
- HSRP and Standby Command Switches, page 7-12
- IP Addresses, page 7-16
- Host Names, page 7-17
- Passwords, page 7-17
- SNMP Community Strings, page 7-17
- TACACS+ and RADIUS, page 7-18
- Access Modes in CMS, page 7-18
- Management VLAN, page 7-19
- LRE Profiles, page 7-19
- Availability of Switch-Specific Features in Switch Clusters, page 7-20

Refer to the release notes for the list of Catalyst switches eligible for switch clustering, including which ones can be command switches and which ones can only be member switches, and for the required software versions and browser and Java plug-in configurations.

Automatic Discovery of Cluster Candidates and Members

The command switch uses Cisco Discovery Protocol (CDP) to discover member switches, candidate switches, neighboring switch clusters, and edge devices in star or cascaded topologies.

Note Do not disable CDP on the command switch, on cluster members, or on any cluster-capable switches that you might want a command switch to discover. For more information about CDP, see Chapter 21, "Configuring CDP."

Following these connectivity guidelines ensures automatic discovery of the switch cluster, cluster candidates, connected switch clusters, and neighboring edge devices:

- Discovery through CDP Hops, page 7-6
- Discovery through Non-CDP-Capable and Noncluster-Capable Devices, page 7-8
- Discovery through the Same Management VLAN, page 7-9
- Discovery through Different Management VLANs, page 7-10
- Discovery of Newly Installed Switches, page 7-11

Discovery through CDP Hops

By using CDP, a command switch can discover switches up to seven CDP hops away (the default is three hops) from the edge of the cluster. The edge of the cluster is where the last member switches are connected to the cluster and to candidate switches. For example, member switches 9 and 10 in Figure 7-1 are at the edge of the cluster.

You can set the number of hops the command switch searches for candidate and member switches by selecting **Cluster** > **Hop Count**. When new candidate switches are added to the network, the command switch discovers them and adds them to the list of candidate switches.

In Figure 7-1, the command switch is running a release earlier than Release 12.1(9)EA1 and has ports assigned to management VLAN 16. In Figure 7-2, the command switch is running Release 12.1(9)EA1 or later and has ports assigned to VLANs 16 and 62. The CDP hop count is three. Each command switch discovers switches 11, 12, 13, and 14 because they are within three hops from the edge of the cluster. It does not discover switch 15 because it is four hops from the edge of the cluster.

Figure 7-1 Discovery through CDP Hops (Command Switch Running a Release Earlier than Release 12.1(9)EA1)

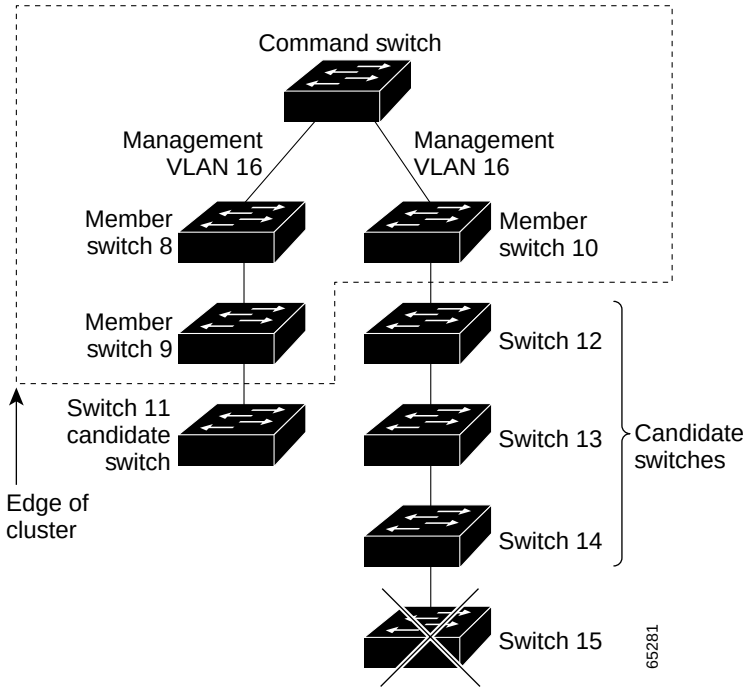
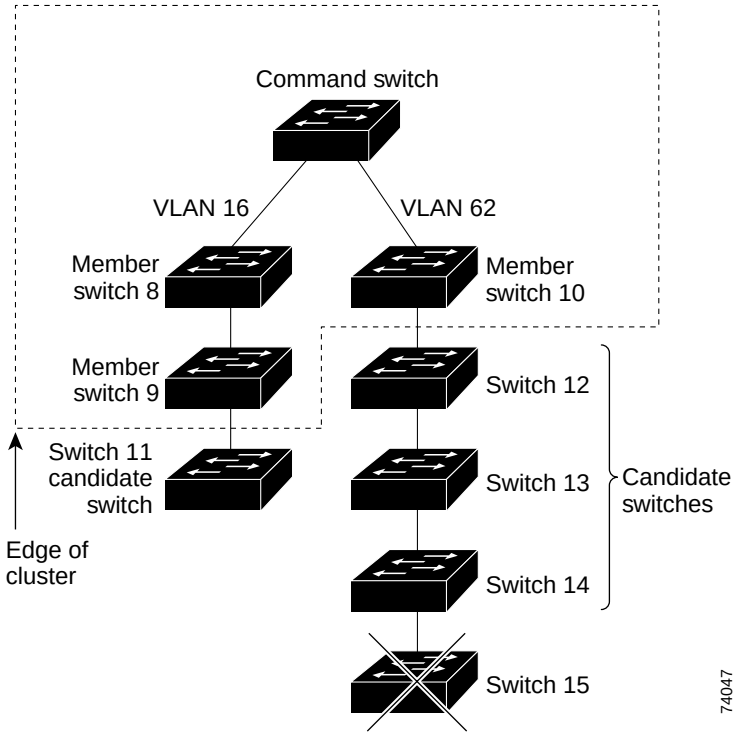


Figure 7-2 Discovery through CDP Hops (Command Switch Running Release 12.1(9)EA1 or Later)



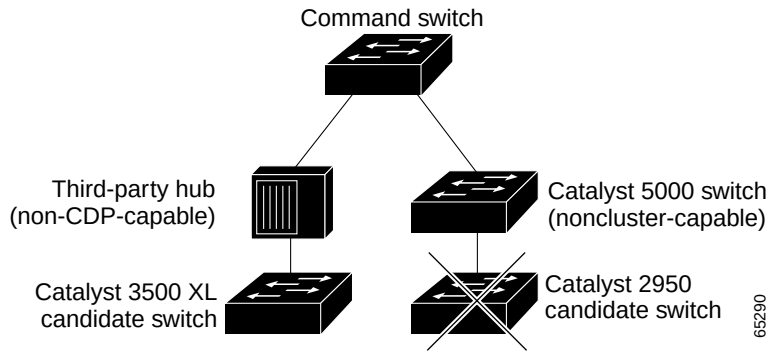
Discovery through Non-CDP-Capable and Noncluster-Capable Devices

If a command switch is connected to a *non-CDP-capable third-party hub* (such as a non-Cisco hub), it can discover cluster-enabled devices connected to that third-party hub. However, if the command switch is connected to a *noncluster-capable Cisco device*, it cannot discover a cluster-enabled device connected beyond the noncluster-capable Cisco device.

Figure 7-3 shows that the command switch discovers the Catalyst 3500 XL switch, which is connected to a third-party hub. However, the command switch does not discover the Catalyst 2950 switch that is connected to a Catalyst 5000 switch.

Refer to the release notes for the Catalyst switches that can be part of a switch cluster.

Figure 7-3 Discovery through Non-CDP-Capable and Noncluster-Capable Devices



Discovery through the Same Management VLAN

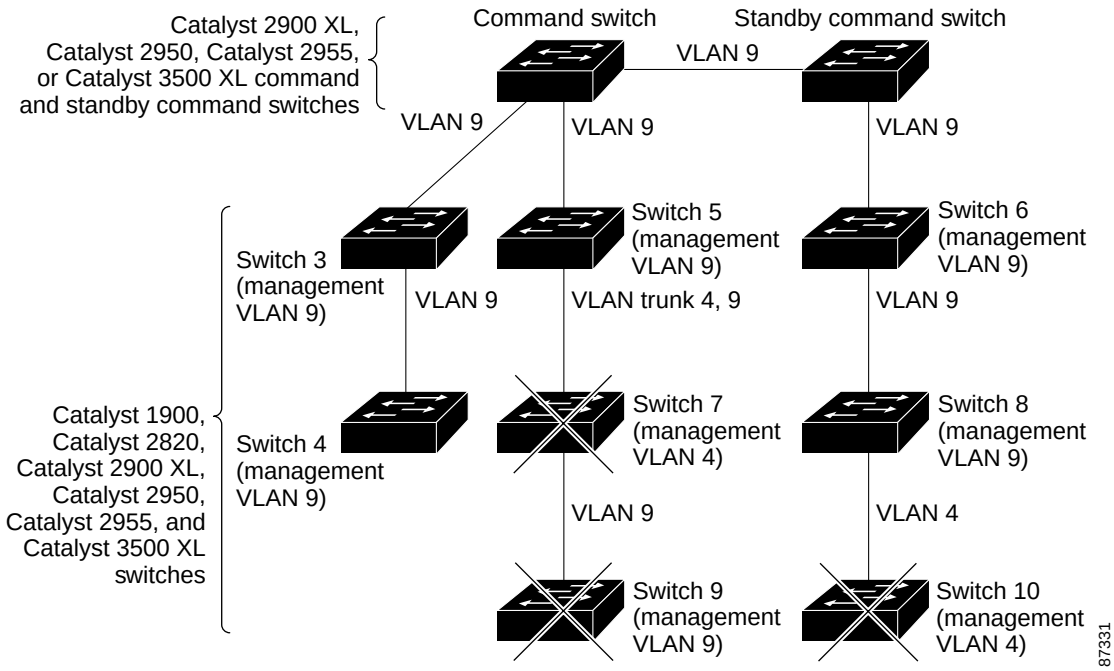
A Catalyst 2900 XL command switch, a Catalyst 2950 command switch running a release earlier than Release 12.1(9)EA1, or a Catalyst 3500 XL command switch must connect to all cluster members through its management VLAN. The default management VLAN is VLAN 1. For more information about management VLANs, see the "Management VLAN" section on page 7-19.

Note You can avoid this limitation by using, whenever possible, a Catalyst 3550 command switch, a Catalyst 2955 switch running Release 12.1(12c)EA1 or later, or a Catalyst 2950 command switch running Release 12.1(9)EA1 or later. These command switches can manage cluster members even if they belong to different management VLANs. See the "Discovery through Different Management VLANs" section on page 7-10.

The command switch in Figure 7-4 has ports assigned to management VLAN 9. It discovers all but these switches:

- Switches 7 and 10 because their management VLAN (VLAN 4) is different from the command-switch management VLAN (VLAN 9)
- Switch 9 because automatic discovery does not extend beyond a noncandidate device, which is switch 7

Figure 7-4 Discovery through the Same Management VLAN


Catalyst 2900 XL, Catalyst 2950, Catalyst 2955, or Catalyst 3500 XL command and standby command switches
Command switch
Standby command switch
VLAN 9
VLAN 9
VLAN 9
VLAN 9
Switch 5 (management VLAN 9)
Switch 6 (management VLAN 9)
Switch 3 (management VLAN 9)
VLAN 9
VLAN trunk 4, 9
VLAN 9
Catalyst 1900, Catalyst 2820, Catalyst 2900 XL, Catalyst 2950, Catalyst 2955, and Catalyst 3500 XL switches
Switch 4 (management VLAN 9)
Switch 7 (management VLAN 4)
Switch 8 (management VLAN 9)
VLAN 9
VLAN 4
Switch 9 (management VLAN 9)
Switch 10 (management VLAN 4)
87331

Discovery through Different Management VLANs

We recommend using a Catalyst 3550 command switch, a Catalyst 2955 command switch running Release 12.1(12c)EA1 or later, or a Catalyst 2950 command switch running Release 12.1(9)EA1 or later. These command switches can discover and manage member switches in different VLANs and different management VLANs. Catalyst 3550 member switches, Catalyst 2955 member switches running Release 12.1(12c)EA1 or later, and Catalyst 2950 member switches running Release 12.1(9)EA1 or later must be connected through at least one VLAN in common with the command switch. All other member switches must be connected to the command switch through their management VLAN.

In contrast, a Catalyst 2900 XL command switch, a Catalyst 2950 command switch running a release earlier than Release 12.1(9)EA1, or a Catalyst 3500 XL command switch must connect to all cluster members through its management VLAN. The default management VLAN is VLAN 1. For information about discovery through the same management VLAN on these switches, see the "Discovery through the Same Management VLAN" section on page 7-9.

The Catalyst 2950 command switch (running Release 12.1(9)EA1 or later) in Figure 7-5 and the Catalyst 3550 command switch in Figure 7-6 have ports assigned to VLANs 9, 16, and 62. The management VLAN on the Catalyst 2950 command switch is VLAN 9. Each command switch discovers the switches in the different management VLANs except these:

- Switches 7 and 10 (switches in management VLAN 4) because they are not connected through a common VLAN (meaning VLANs 62 and 9) with the command switch
- Switch 9 because automatic discovery does not extend beyond a noncandidate device, which is switch 7

Figure 7-5 Discovery through Different Management VLANs with a Layer 2 Command Switch

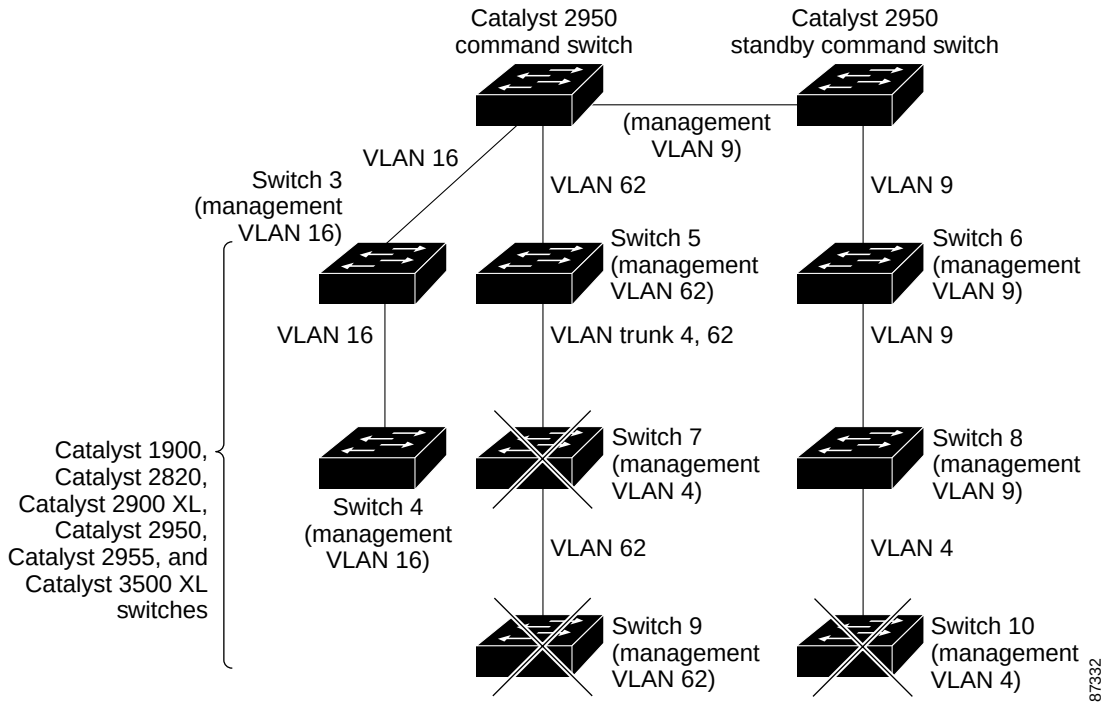
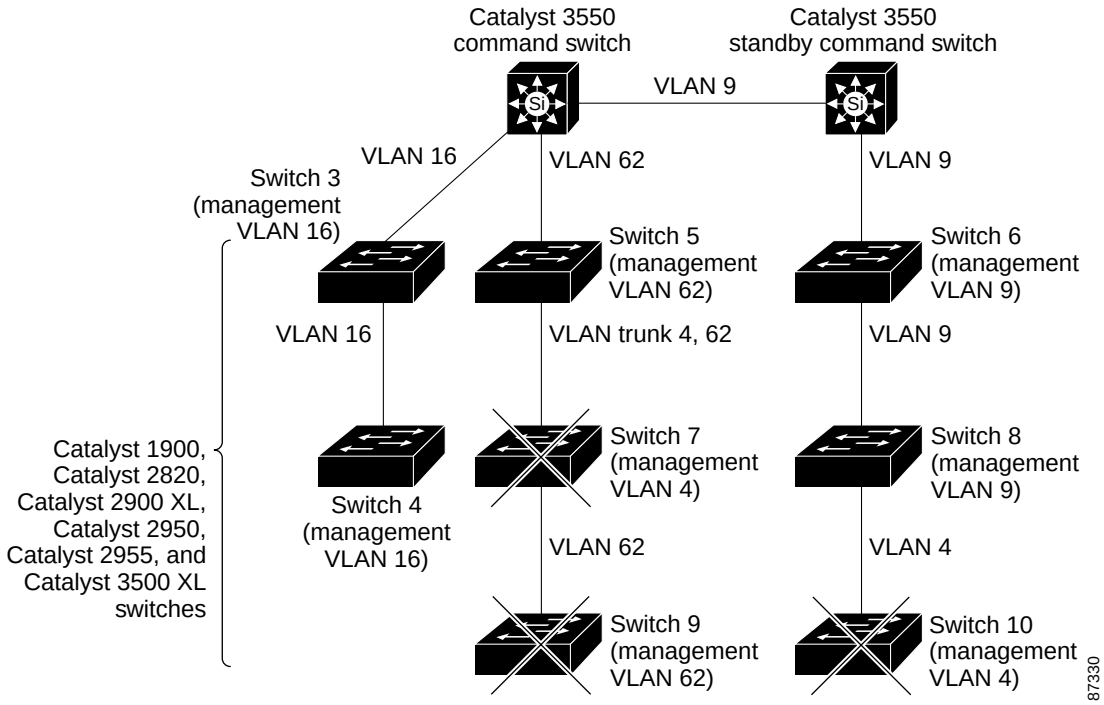


Figure 7-6 Discovery through Different Management VLANs with a Layer 3 Command Switch



Discovery of Newly Installed Switches

To join a cluster, the new, out-of-the-box switch must be connected to the cluster through one of its access ports. An access port (AP) carries the traffic of and belongs to the management VLAN. By default, the new switch and its access ports are assigned to management VLAN 1.

When the new switch joins a cluster, its default management VLAN changes to the VLAN of the immediately upstream neighbor. The new switch also configures its access port to belong to the VLAN of the immediately upstream neighbor.

The command switch (running a release earlier than Release 12.1(9)EA1) in Figure 7-7 belongs to management VLAN 16. When the new Catalyst 2900 LRE XL and Catalyst 2950 switches join the cluster, their management VLAN and access ports change from VLAN 1 to VLAN 16.

The command switch (running Release 12.1(9)EA1 or later) in Figure 7-8 belongs to VLANs 9 and 16. When the new Catalyst 3550 and Catalyst 2950 switches join the cluster:

- The Catalyst 3550 switch and its access port are assigned to VLAN 9.
- The Catalyst 2950 switch and its access port are assigned to management VLAN 16.

Figure 7-7 Discovery of Newly Installed Switches in the Same Management VLAN

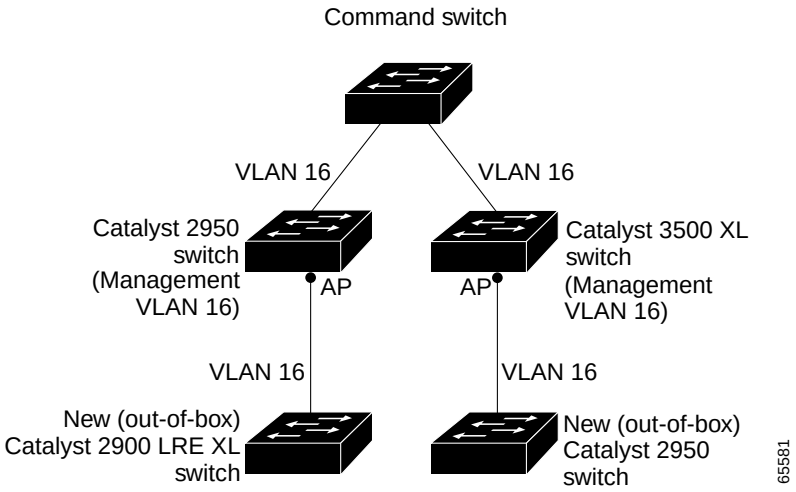
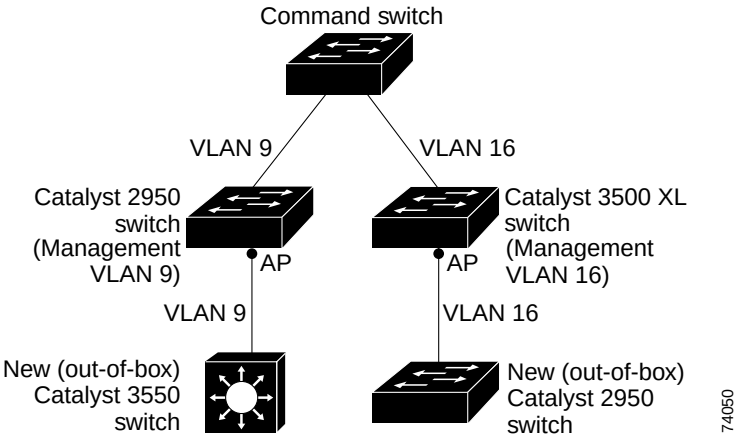


Figure 7-8 Discovery of Newly Installed Switches in Different Management VLANs



HSRP and Standby Command Switches

The switch supports Hot Standby Router Protocol (HSRP) so that you can configure a group of standby command switches. Because a command switch manages the forwarding of all communication and configuration information to all the member switches, we strongly recommend that you configure a cluster standby command switch to take over if the primary command switch fails.

A *cluster standby group* is a group of command-capable switches that meet the requirements described in the "Standby Command Switch Characteristics" section on page 7-3. Only one cluster standby group can be assigned per cluster.

Note

- When the command switch is a Catalyst 3550 switch, all standby command switches must be Catalyst 3550 switches.
- When the command switch is a Catalyst 2955 switch running Release 12.1(12c)EA1 or later, all standby command switches must be Catalyst 2955 switches running Release 12.1(12c)EA1 or later.
- When the command switch is a Catalyst 2950 switch running Release 12.1(9)EA1 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(9)EA1 or later.
- When the command switch is a Catalyst 2950 switch running Release 12.1(6)EA2 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(6)EA2 or later.
- When the command switch is running Release 12.0(5)WC2 or earlier, the standby command switches can be these switches: Catalyst 2900 XL, Catalyst 2950, and Catalyst 3500 XL switches.

Note The cluster standby group is an HSRP group. Disabling HSRP disables the cluster standby group.

The switches in the cluster standby group are ranked according to HSRP priorities. The switch with the highest priority in the group is the *active command switch* (AC). The switch with the next highest priority is the *standby command switch* (SC). The other switches in the cluster standby group are the *passive command switches* (PC). If the active command switch and the standby command switch become disabled *at the same time*, the passive command switch with the highest priority becomes the active command switch. For the limitations to automatic discovery, see the "Automatic Recovery of Cluster Configuration" section on page 7-15. For information about changing HSRP priority values, refer to the **standby priority** interface configuration mode command in the IOS Release 12.1 documentation set. The HSRP commands are the same for changing the priority of cluster standby group members and router-redundancy group members.

Note The HSRP standby hold time interval should be greater than or equal to 3 times the hello time interval. The default HSRP standby hold time interval is 10 seconds. The default HSRP standby hello time interval is 3 seconds. For more information about the standby hold time and hello time intervals, refer to the Release 12.1 documentation set on Cisco.com.

These connectivity guidelines ensure automatic discovery of the switch cluster, cluster candidates, connected switch clusters, and neighboring edge devices. These topics also provide more detail about standby command switches:

- Virtual IP Addresses, page 7-13
- Other Considerations for Cluster Standby Groups, page 7-14
- Automatic Recovery of Cluster Configuration, page 7-15

Virtual IP Addresses

You need to assign a unique virtual IP address and group number and name to the cluster standby group. This information must be configured on the management VLAN on the active command switch. The active command switch receives traffic destined for the virtual IP address. To manage the cluster, you must access the active command switch through the virtual IP address, not through the command-switch IP address. This is in case the IP address of the active command switch is different from the virtual IP address of the cluster standby group.

If the active command switch fails, the standby command switch assumes ownership of the virtual IP address and becomes the active command switch. The passive switches in the cluster standby group compare their assigned priorities to determine the new standby command switch. The passive standby switch with the highest priority then becomes the standby command switch. When the previously active command switch becomes active again, it resumes its role as the active command switch, and the current active command switch becomes the standby command switch again. For more information about IP address in switch clusters, see the "IP Addresses" section on page 7-16.

Other Considerations for Cluster Standby Groups

These requirements also apply:

- Standby command switches must meet these requirements:
  - When the command switch is a Catalyst 3550 switch, all standby command switches must be Catalyst 3550 switches.
  - When the command switch is a Catalyst 2955 switch running Release 12.1(12c)EA1 or later, all standby command switches must be Catalyst 2955 switches running Release 12.1(12c)EA1 or later.
  - When the command switch is a Catalyst 2950 switch running Release 12.1(9)EA1 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(9)EA1 or later.
  - When the command switch is a Catalyst 2950 switch running Release 12.1(6)EA2 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(6)EA2 or later.
  - When the command switch is running Release 12.0(5)WC2 or earlier, the standby command switches can be these switches: Catalyst 2900 XL, Catalyst 2950, and Catalyst 3500 XL switches.

  We strongly recommend that the command switch and standby command switches are of the same switch platform.
  - If you have a Catalyst 3550 command switch, the standby command switches should be Catalyst 3550 switches.
  - If you have a Catalyst 2955 command switch, the standby command switches should be Catalyst 2955 switches.
  - If you have a Catalyst 2950 command switch, the standby command switches should be Catalyst 2950 switches.
  - If you have a Catalyst 2900 XL or Catalyst 3500 XL command switch, the standby command switches should be Catalyst 2900 XL and Catalyst 3500 XL switches.
- Only one cluster standby group can be assigned to a cluster.
- All standby-group members must be members of the cluster.

Note There is no limit to the number of switches that you can assign as standby command switches. However, the total number of switches in the cluster—which would include the active command switch, standby-group members, and member switches—cannot be more than 16.

- Each standby-group member (Figure 7-9) must be connected to the command switch through its management VLAN. Each standby-group member must also be redundantly connected to each other through the management VLAN.

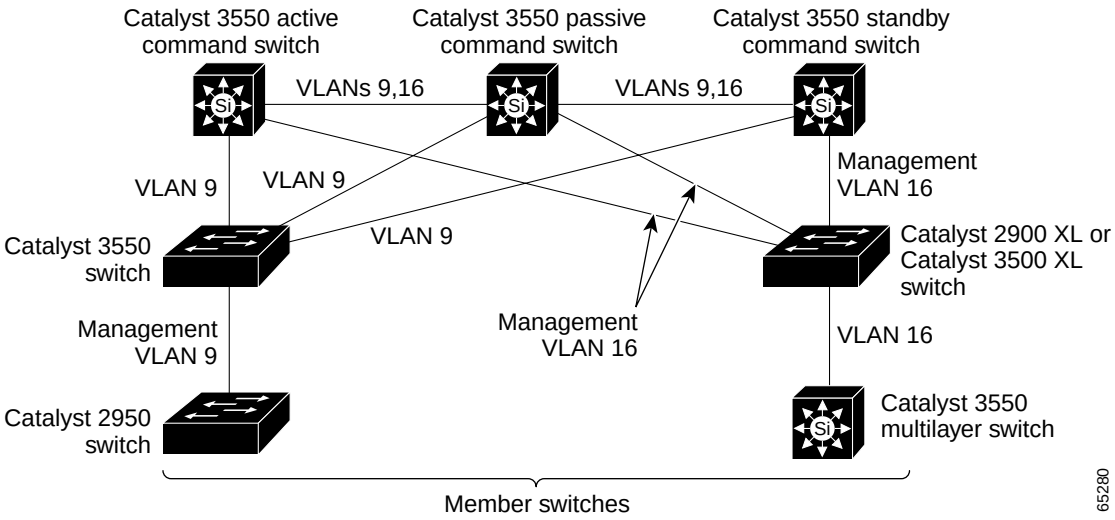
  Catalyst 1900, Catalyst 2820, Catalyst 2900 XL, Catalyst 2950, Catalyst 2955, and Catalyst 3500 XL member switches must be connected to the cluster standby group through their management VLANs.

Note Catalyst 2950 standby command switches running Release 12.1(9)EA1 or later can connect to candidate and member switches in VLANs different from their management VLANs. Catalyst 2955 standby command switches running Release 12.1(12c)EA1 or later can connect to candidate and member switches in VLANs different from their management VLANs.

For more information about VLANs in switch clusters, see these sections:

- "Discovery through the Same Management VLAN" section on page 7-9
- "Discovery through Different Management VLANs" section on page 7-10

Figure 7-9 VLAN Connectivity between Standby-Group Members and Cluster Members



Automatic Recovery of Cluster Configuration

The active command switch continually forwards cluster-configuration information (but not device-configuration information) to the standby command switch. This ensures that the standby command switch can take over the cluster immediately after the active command switch fails.

Automatic discovery has these limitations:

- This limitation applies only to clusters that have Catalyst 2950, Catalyst 2955, and Catalyst 3550 command and standby command switches: If the active command switch and standby command switch become disabled *at the same time*, the passive command switch with the highest priority becomes the active command switch. However, because it was a passive standby command switch, the previous command switch *did not* forward cluster-configuration information to it. The active command switch only forwards cluster-configuration information to the standby command switch. You must therefore rebuild the cluster.
- This limitation applies to all clusters: If the active command switch fails and there are more than two switches in the cluster standby group, the new command switch does not discover any Catalyst 1900, Catalyst 2820, and Catalyst 2916M XL member switches. You must re-add these member switches to the cluster.
- This limitation applies to all clusters: If the active command switch fails and becomes active again, it does not discover any Catalyst 1900, Catalyst 2820, and Catalyst 2916M XL member switches. You must again add these member switches to the cluster.

When the previously active command switch resumes its active role, it receives a copy of the latest cluster configuration from the active command switch, including members that were added while it was down. The active command switch sends a copy of the cluster configuration to the cluster standby group.

IP Addresses

You must assign IP information to a command switch. You can access the cluster through the command-switch IP address. If you configure a cluster standby group, you must use the standby-group virtual IP address to manage the cluster from the active command switch. Using the virtual IP address ensures that you retain connectivity to the cluster if the active command switch fails and that a standby command switch becomes the active command switch.

If the active command switch fails and the standby command switch takes over, you must either use the standby-group virtual IP address or the IP address available on the new active command switch to access the cluster.

You can assign an IP address to a cluster-capable switch, but it is not necessary. A member switch is managed and communicates with other member switches through the command-switch IP address. If the member switch leaves the cluster and it does not have its own IP address, you then must assign IP information to it to manage it as a standalone switch.

Note Changing the command switch IP address ends your CMS session on the switch. Restart your CMS session by entering the new IP address in the browser **Location** field (Netscape Communicator) or **Address** field (Internet Explorer), as described in the release notes.

For more information about IP addresses, see Chapter 5, “Assigning the Switch IP Address and Default Gateway.”

Host Names

You do not need to assign a host name to either a command switch or an eligible cluster member. However, a host name assigned to the command switch can help to identify the switch cluster. The default host name for the switch is *Switch*.

If a switch joins a cluster and it does not have a host name, the command switch appends a unique member number to its own host name and assigns it sequentially as each switch joins the cluster. The number means the order in which the switch was added to the cluster. For example, a command switch named *eng-cluster* could name the fifth cluster member *eng-cluster-5*.

If a switch has a host name, it retains that name when it joins a cluster. It retains that host name even after it leaves the cluster.

If a switch received its host name from the command switch, was removed from a cluster, was then added to a new cluster, and kept the same member number (such as *5*), the old host name (such as *eng-cluster-5*) is overwritten with the host name of the command switch in the new cluster (such as *mkg-cluster-5*). If the switch member number changes in the new cluster (such as *3*), the switch retains the previous name (*eng-cluster-5*).

Passwords

You do not need to assign passwords to an individual switch if it will be a cluster member. When a switch joins a cluster, it inherits the command-switch password and retains it when it leaves the cluster. If no command-switch password is configured, the member switch inherits a null password. Member switches only inherit the command-switch password.

If you change the member-switch password to be different from the command-switch password and save the change, the switch is not manageable by the command switch until you change the member-switch password to match the command-switch password. Rebooting the member switch does not revert the password back to the command-switch password. We recommend that you do not change the member-switch password after it joins a cluster.

For more information about passwords, see the "Preventing Unauthorized Access to Your Switch" section on page 9-1.

For password considerations specific to the Catalyst 1900 and Catalyst 2820 switches, refer to the installation and configuration guides for those switches.

SNMP Community Strings

A member switch inherits the command-switch first read-only (RO) and read-write (RW) community strings with *@esN* appended to the community strings:

- *command-switch-readonly-community-string@esN*, where *N* is the member-switch number.
- *command-switch-readwrite-community-string@esN*, where *N* is the member-switch number.

If the command switch has multiple read-only or read-write community strings, only the first read-only and read-write strings are propagated to the member switch.

The switches support an unlimited number of community strings and string lengths. For more information about SNMP and community strings, see Chapter 25, "Configuring SNMP."

For SNMP considerations specific to the Catalyst 1900 and Catalyst 2820 switches, refer to the installation and configuration guides specific to those switches.

TACACS+ and RADIUS

Inconsistent authentication configurations in switch clusters cause CMS to continually prompt for a user name and password. If Terminal Access Controller Access Control System Plus (TACACS+) is configured on a cluster member, it must be configured on all cluster members. Similarly, if Remote Authentication Dial-In User Service (RADIUS) is configured on a cluster member, it must be configured on all cluster members. Further, the same switch cluster cannot have some members configured with TACACS+ and other members configured with RADIUS.

For more information about TACACS+, see the "Controlling Switch Access with TACACS+" section on page 9-9. For more information about RADIUS, see the "Controlling Switch Access with RADIUS" section on page 9-17.

Access Modes in CMS

CMS provides two levels of access to the configuration options: read-write access and read-only access. Privilege levels 0 to 15 are supported.

- Privilege level 15 provides you with read-write access to CMS.
- Privilege levels 1 to 14 provide you with read-only access to CMS. Any options in the CMS windows, menu bar, toolbar, and popup menus that change the switch or cluster configuration are not shown in read-only mode.
- Privilege level 0 denies access to CMS.

For more information about CMS access modes, see the "Access Modes in CMS" section on page 4-30.

Note

- If your cluster has these member switches running earlier software releases and if you have read-only access to these member switches, some configuration windows for those switches display incomplete information:
  - Catalyst 2900 XL or Catalyst 3500 XL member switches running Release 12.0(5)WC2 or earlier
  - Catalyst 2950 member switches running Release 12.0(5)WC2 or earlier
  - Catalyst 3550 member switches running Release 12.1(6)EA1 or earlier

  For more information about this limitation, refer to the release notes.
- These switches do not support read-only mode on CMS:
  - Catalyst 1900 and Catalyst 2820
  - Catalyst 2900 XL switches with 4-MB CPU DRAM

  In read-only mode, these switches appear as unavailable devices and cannot be configured from CMS.

Management VLAN

Communication with the switch management interfaces is through the command-switch IP address. The IP address is associated with the management VLAN, which by default is VLAN 1. To manage switches in a cluster, the command switch, member switches, and candidate switches must be connected through ports assigned to the command-switch management VLAN.

Note

- If the command switch is a Catalyst 2950 running Release 12.1(9)EA1 or later or a Catalyst 2955 running Release 12 1(12c)EA1 or later, candidate and member switches can belong to different management VLANs. However, they must connect to the command switch through their management VLAN.
- Catalyst 2950 standby command switches running Release 12.1(9)EA1 or later and Catalyst 2955 standby command switches running Release 121.(12c)EA1 can connect to candidate and member switches in VLANs different from their management VLANs.

If you add a new, out-of-box switch to a cluster and the cluster is using a management VLAN other than the default VLAN 1, the command switch automatically senses that the new switch has a different management VLAN and has not been configured. The command switch issues commands to change the management VLAN of the new switch to the one the cluster is using. This automatic VLAN change only occurs for new, out-of-box switches that do not have a config.text file and that have no changes to the running configuration. For more information, see the "Discovery of Newly Installed Switches" section on page 7-11.

You can change the management VLAN of a member switch (not the command switch). However, the command switch will not be able to communicate with it. In this case, you will need to manage the switch as a standalone switch.

You can globally change the management VLAN for the cluster as long as each member switch has either a trunk connection or a connection to the new command-switch management VLAN. From the command switch, use the **cluster management vlan** global configuration command to change the cluster management VLAN to a different management VLAN.

Caution

You can change the management VLAN through a console connection without interrupting the console connection. However, changing the management VLAN ends your CMS session. Restart your CMS session by entering the new IP address in the browser **Location** field (Netscape Communicator) or **Address** field (Microsoft Internet Explorer), as described in the release notes.

For more information about changing the management VLAN, see the "Management VLAN" section on page 7-19.

LRE Profiles

A configuration conflict occurs if a switch cluster has Long-Reach Ethernet (LRE) switches that use both private and public profiles. If one LRE switch in a cluster is assigned a public profile, all LRE switches in that cluster must have that same public profile. Before you add an LRE switch to a cluster, make sure that you assign it the same public profile used by other LRE switches in the cluster.

A cluster can have a mix of LRE switches that use different private profiles.

Availability of Switch-Specific Features in Switch Clusters

The menu bar on the command switch displays all options available from the switch cluster. Therefore, features specific to a member switch are available from the command-switch menu bar. For example, **Device** > **LRE Profile** appears in the command-switch menu bar when at least one Catalyst 2900 LRE XL switch is in the cluster.

Creating a Switch Cluster

Using CMS to create a cluster is easier than using the CLI commands. This section provides this information:

- Enabling a Command Switch, page 7-20
- Adding Member Switches, page 7-21
- Creating a Cluster Standby Group, page 7-23
- Verifying a Switch Cluster, page 7-26

This section assumes you have already cabled the switches, as described in the switch hardware installation guide, and followed the guidelines described in the "Planning a Switch Cluster" section on page 7-5.

Note Refer to the release notes for the list of Catalyst switches eligible for switch clustering, including which ones can be command switches and which ones can only be member switches, and for the required software versions and browser and Java plug-in configurations.

Enabling a Command Switch

The switch you designate as the command switch must meet the requirements described in the "Command Switch Characteristics" section on page 7-3, the "Planning a Switch Cluster" section on page 7-5, and the release notes.

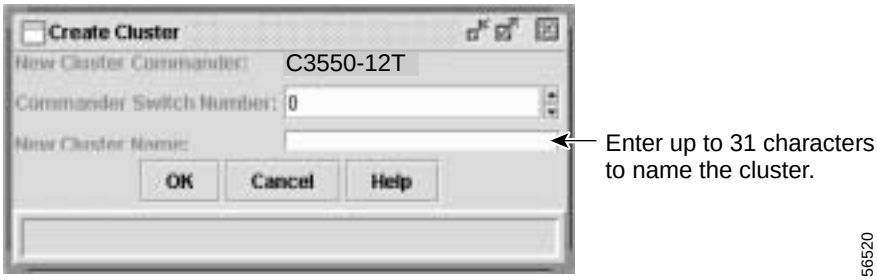
Note

- We strongly recommend that the highest-end, command-capable switch in the cluster be the command switch:
  - If your switch cluster has a Catalyst 3550 switch, that switch should be the command switch.
  - If your switch cluster has Catalyst 2900 XL, Catalyst 2950, Catalyst 2955, and Catalyst 3500 XL switches, the Catalyst 2950 or Catalyst 2955 switch should be the command switch.
  - If your switch cluster has Catalyst 1900, Catalyst 2820, Catalyst 2900 XL, and Catalyst 3500 XL switches, either the Catalyst 2900 XL or Catalyst 3500 XL switch should be the command switch.

You can enable a command switch, name the cluster, and assign an IP address and a password to the command switch when you run the setup program during initial switch setup. For information about using the setup program, refer to the release notes.

If you did not enable a command switch during initial switch setup, launch Device Manager from a command-capable switch, and select **Cluster > Create Cluster**. Enter a cluster number (the default is 0), and use up to 31 characters to name the cluster (Figure 7-10). Instead of using CMS to enable a command switch, you can use the **cluster enable** global configuration command.

Figure 7-10 Create Cluster Window



Adding Member Switches

As explained in the "Automatic Discovery of Cluster Candidates and Members" section on page 7-6, the command switch automatically discovers candidate switches. When you add new cluster-capable switches to the network, the command switch discovers them and adds them to a list of candidate switches. To display an updated cluster candidates list from the Add to Cluster window (Figure 7-11), either relaunch CMS and redisplay this window, or follow these steps:

1. Close the Add to Cluster window.
2. Select **View > Refresh**.
3. Select **Cluster > Add to Cluster** to redisplay the Add to Cluster window.

From CMS, there are two ways to add switches to a cluster:

- Select **Cluster > Add to Cluster**, select a candidate switch from the list, click **Add**, and click **OK**. To add more than one candidate switch, press **Ctrl**, and make your choices, or press **Shift**, and choose the first and last switch in a range.
- Display the Topology view, right-click a candidate-switch icon, and select **Add to Cluster** (Figure 7-12). In the Topology view, candidate switches are cyan, and member switches are green. To add more than one candidate switch, press **Ctrl**, and left-click the candidates that you want to add.

Instead of using CMS to add members to the cluster, you can use the **cluster member** global configuration command from the command switch. Use the **password** option in this command if the candidate switch has a password.

You can select 1 or more switches as long as the total number of switches in the cluster does not exceed 16 (this includes the command switch). When a cluster has 16 members, the **Add to Cluster** option is not available for that cluster. In this case, you must remove a member switch before adding a new one.

If a password has been configured on a candidate switch, you are prompted to enter it before it can be added it to the cluster. If the candidate switch does not have a password, any entry is ignored.

If multiple candidates switches have the same password, you can select them as a group, and add them at the same time.

If a candidate switch in the group has a password different from the group, only that specific candidate switch is not added to the cluster.

When a candidate switch joins a cluster, it inherits the command-switch password. For more information about setting passwords, see the "Passwords" section on page 7-17.

For additional authentication considerations in switch clusters, see the "TACACS+ and RADIUS" section on page 7-18.

Figure 7-11 Add to Cluster Window

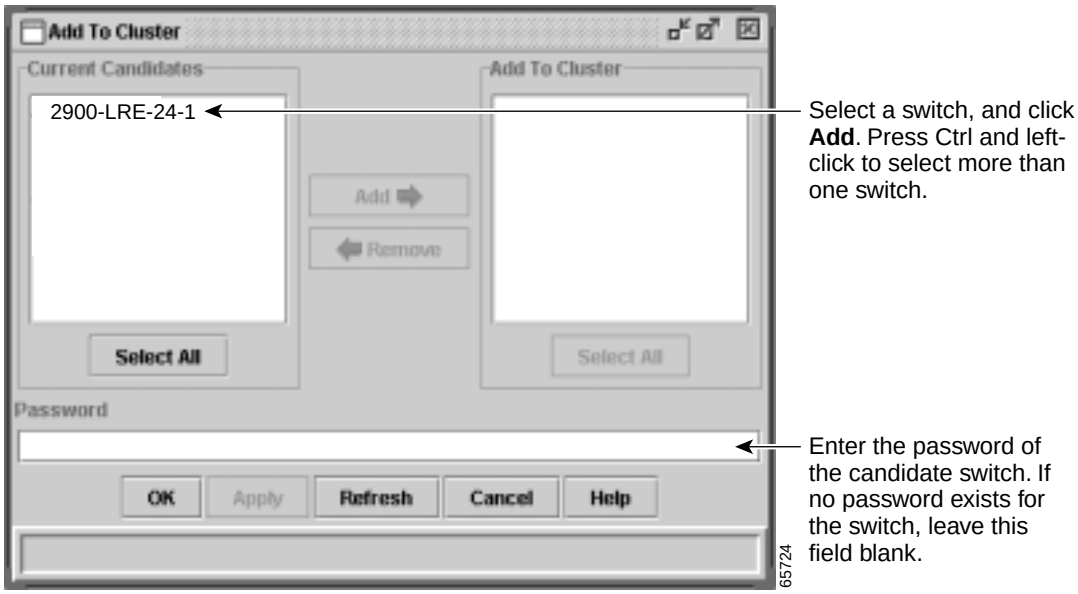
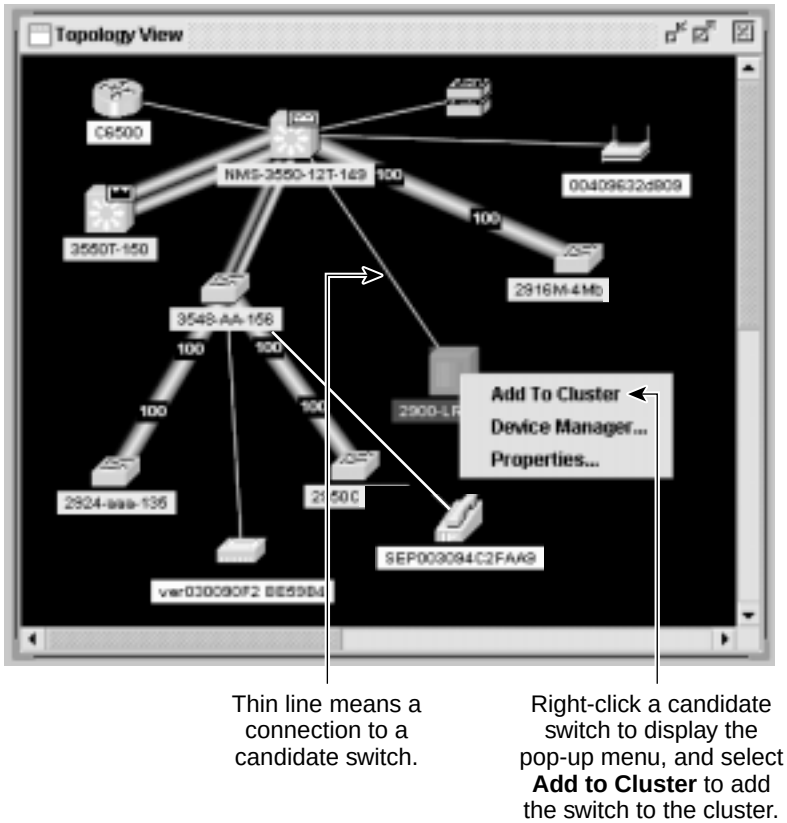


Figure 7-12 Using the Topology View to Add Member Switches



Creating a Cluster Standby Group

The cluster standby group members must meet the requirements described in the "Standby Command Switch Characteristics" section on page 7-3 and "HSRP and Standby Command Switches" section on page 7-12. To create a cluster standby group, select **Cluster > Standby Command Switches** (Figure 7-13).

Instead of using CMS to add switches to a standby group and to bind the standby group to a cluster, you can use the **standby ip**, the **standby name**, and the **standby priority** interface configuration commands and the **cluster standby group** global configuration command.

Note

- When the command switch is a Catalyst 3550 switch, all standby command switches must be Catalyst 3550 switches.
- When the command switch is a Catalyst 2955 switch running Release 12.1(12c)EA1 or later, all standby command switches must be Catalyst 2955 switches running Release 12.1(12c)EA1 or later.
- When the command switch is a Catalyst 2950 switch running Release 12.1(9)EA1 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(9)EA1 or later.
- When the command switch is a Catalyst 2950 switch running Release 12.1(6)EA2 or later, all standby command switches must be Catalyst 2950 switches running Release 12.1(6)EA2 or later.
- When the command switch is running Release 12.0(5)WC2 or earlier, the standby command switches can be these switches: Catalyst 2900 XL, Catalyst 2950, and Catalyst 3500 XL switches.

These abbreviations are appended to the switch host names in the Standby Command Group list to show their eligibility or status in the cluster standby group:

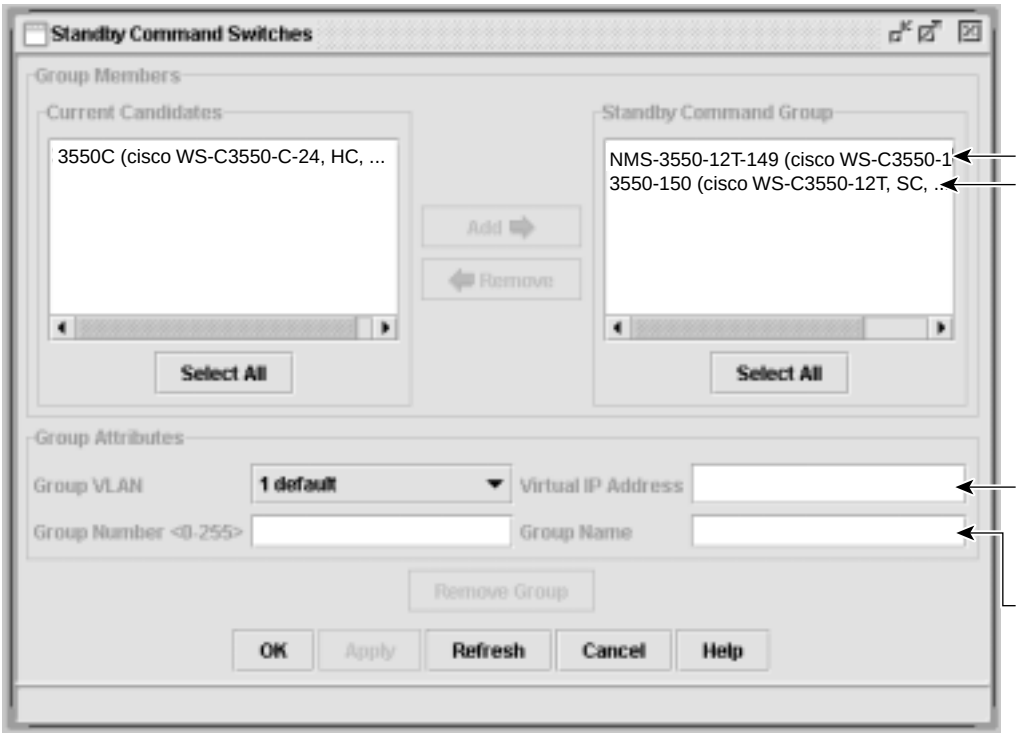
- AC—Active command switch
- SC—Standby command switch
- PC—Member of the cluster standby group but not the standby command switch
- HC—Candidate switch that can be added to the cluster standby group
- CC—Command switch when HSRP is disabled

You must enter a virtual IP address for the cluster standby group. This address must be in the same subnet as the IP addresses of the switch. The group number must be unique within the IP subnet. It can be from 0 to 255, and the default is 0. The group name can have up to 31 characters.

The Standby Command Configuration window uses the default values for the **preempt** and **name** commands that you have set by using the CLI. If you use this window to create the HSRP group, all switches in the group have the **preempt** command enabled. You must also provide a name for the group.

Note The HSRP standby hold time interval should be greater than or equal to 3 times the hello time interval. The default HSRP standby hold time interval is 10 seconds. The default HSRP standby hello time interval is 3 seconds. For more information about the standby hold time and hello time intervals, refer to the Cisco IOS Release 12.1 documentation set on Cisco.com.

Figure 7-13 Standby Command Configuration Window



Verifying a Switch Cluster

When you finish adding cluster members, follow these steps to verify the cluster:

Step 1 Enter the command switch IP address in the browser **Location** field (Netscape Communicator) or **Address** field (Microsoft Internet Explorer) to access all switches in the cluster.

Step 2 Enter the command-switch password.

Step 3 Select **View** > **Topology** to display the cluster topology and to view link information. For complete information about the Topology view, including descriptions of the icons, links, and colors, see the "Topology View" section on page 4-10.

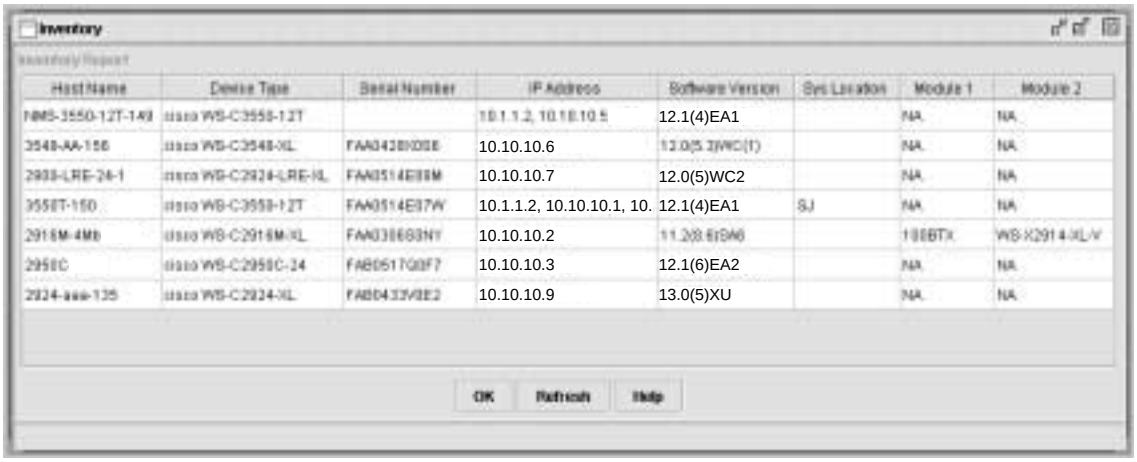
Step 4 Select **Reports** > **Inventory** to display an inventory of the switches in the cluster (Figure 7-14).

The summary includes information such as switch model numbers, serial numbers, software versions, IP information, and location.

You can also display port and switch statistics from **Reports** > **Port Statistics** and **Port** > **Port Settings** > **Runtime Status**.

Instead of using CMS to verify the cluster, you can use the **show cluster members** user EXEC command from the command switch or use the **show cluster** user EXEC command from the command switch or from a member switch.

Figure 7-14 Inventory Window



If you lose connectivity with a member switch or if a command switch fails, see the "Using Recovery Procedures" section on page 29-1.

For more information about creating and managing clusters, refer to the online help. For information about the cluster commands, refer to the switch command reference.

Using the CLI to Manage Switch Clusters

You can configure member switches from the CLI by first logging into the command switch. Enter the **rcommand** user EXEC command and the member switch number to start a Telnet session (through a console or Telnet connection) and to access the member switch CLI. The command mode changes, and the IOS commands operate as usual. Enter the **exit** privileged EXEC command on the member switch to return to the command-switch CLI.

This example shows how to log into member-switch 3 from the command-switch CLI:

```
switch# rcommand 3
```

If you do not know the member-switch number, enter the **show cluster members** privileged EXEC command on the command switch. For more information about the **rcommand** command and all other cluster commands, refer to the switch command reference.

The Telnet session accesses the member-switch CLI at the same privilege level as on the command switch. The IOS commands then operate as usual. For instructions on configuring the switch for a Telnet session, see the "Setting a Telnet Password for a Terminal Line" section on page 9-5.

Catalyst 1900 and Catalyst 2820 CLI Considerations

If your switch cluster has Catalyst 1900 and Catalyst 2820 switches running standard edition software, the Telnet session accesses the management console (a menu-driven interface) if the command switch is at privilege level 15. If the command switch is at privilege level 1 to 14, you are prompted for the password to access the menu console.

Command-switch privilege levels map to the Catalyst 1900 and Catalyst 2820 member switches running standard and Enterprise Edition Software as follows:

- If the command-switch privilege level is 1 to 14, the member switch is accessed at privilege level 1.
- If the command-switch privilege level is 15, the member switch is accessed at privilege level 15.

Note The Catalyst 1900 and Catalyst 2820 CLI is available only on switches running Enterprise Edition Software.

For more information about the Catalyst 1900 and Catalyst 2820 switches, refer to the installation and configuration guides for those switches.

Using SNMP to Manage Switch Clusters

When you first power on the switch, SNMP is enabled if you enter the IP information by using the setup program and accept its proposed configuration. If you did not use the setup program to enter the IP information and SNMP was not enabled, you can enable it as described in the "Configuring SNMP" section on page 25-5. On Catalyst 1900 and Catalyst 2820 switches, SNMP is enabled by default.

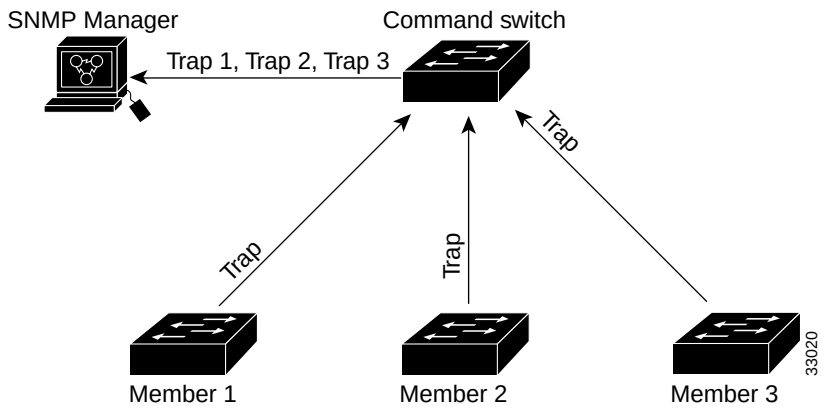
When you create a cluster, the command switch manages the exchange of messages between member switches and an SNMP application. The cluster software on the command switch appends the member switch number (*@esN*, where *N* is the switch number) to the first configured read-write and read-only community strings on the command switch and propagates them to the member switch. The command switch uses this community string to control the forwarding of gets, sets, and get-next messages between the SNMP management station and the member switches.

Note When a cluster standby group is configured, the command switch can change without your knowledge. Use the first read-write and read-only community strings to communicate with the command switch if there is a cluster standby group configured for the cluster.

If the member switch does not have an IP address, the command switch redirects traps from the member switch to the management station, as shown in Figure 7-15. If a member switch has its own IP address and community strings, the member switch can send traps directly to the management station, without going through the command switch.

If a member switch has its own IP address and community strings, they can be used in addition to the access provided by the command switch. For more information about SNMP and community strings, see Chapter 25, "Configuring SNMP."

Figure 7-15 SNMP Management for a Cluster



Administering the Switch

This chapter describes how to perform one-time operations to administer your Catalyst 2950 or Catalyst 2955 switch. This chapter consists of these sections:

- Managing the System Time and Date, page 8-1
- Configuring a System Name and Prompt, page 8-15
- Creating a Banner, page 8-18
- Managing the MAC Address Table, page 8-20
- Managing the ARP Table, page 8-27

Managing the System Time and Date

You can manage the system time and date on your switch using automatic configuration, such as the Network Time Protocol (NTP), or manual configuration methods.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

This section contains this configuration information:

- Understanding the System Clock, page 8-1
- Understanding Network Time Protocol, page 8-2
- Configuring NTP, page 8-3
- Configuring Time and Date Manually, page 8-10

Understanding the System Clock

The heart of the time service is the system clock. This clock runs from the moment the system starts up and keeps track of the date and time.

The system clock can then be set from these sources:

- Network Time Protocol
- Manual configuration

The system clock can provide time to these services:

- User **show** commands
- Logging and debugging messages

The system clock keeps track of time internally based on Universal Time Coordinated (UTC), also known as Greenwich Mean Time (GMT). You can configure information about the local time zone and summer time (daylight saving time) so that the time is correctly displayed for the local time zone.

The system clock keeps track of whether the time is *authoritative* or not (that is, whether it has been set by a time source considered to be authoritative). If it is not authoritative, the time is available only for display purposes and is not redistributed. For configuration information, see the "Configuring Time and Date Manually" section on page 8-10.

Understanding Network Time Protocol

The NTP is designed to time-synchronize a network of devices. NTP runs over User Datagram Protocol (UDP), which runs over IP. NTP is documented in RFC 1305.

An NTP network usually gets its time from an authoritative time source, such as a radio clock or an atomic clock attached to a time server. NTP then distributes this time across the network. NTP is extremely efficient; no more than one packet per minute is necessary to synchronize two devices to within a millisecond of one another.

NTP uses the concept of a *stratum* to describe how many NTP hops away a device is from an authoritative time source. A stratum 1 time server has a radio or atomic clock directly attached, a stratum 2 time server receives its time through NTP from a stratum 1 time server, and so on. A device running NTP automatically chooses as its time source the device with the lowest stratum number with which it communicates through NTP. This strategy effectively builds a self-organizing tree of NTP speakers.

NTP avoids synchronizing to a device whose time might not be accurate by never synchronizing to a device that is not synchronized. NTP also compares the time reported by several devices and does not synchronize to a device whose time is significantly different than the others, even if its stratum is lower.

The communications between devices running NTP (known as *associations*) are usually statically configured; each device is given the IP address of all devices with which it should form associations. Accurate timekeeping is possible by exchanging NTP messages between each pair of devices with an association. However, in a LAN environment, NTP can be configured to use IP broadcast messages instead. This alternative reduces configuration complexity because each device can simply be configured to send or receive broadcast messages. However, in that case, information flow is one-way only.

The time kept on a device is a critical resource; you should use the security features of NTP to avoid the accidental or malicious setting of an incorrect time. Two mechanisms are available: an access list-based restriction scheme and an encrypted authentication mechanism.

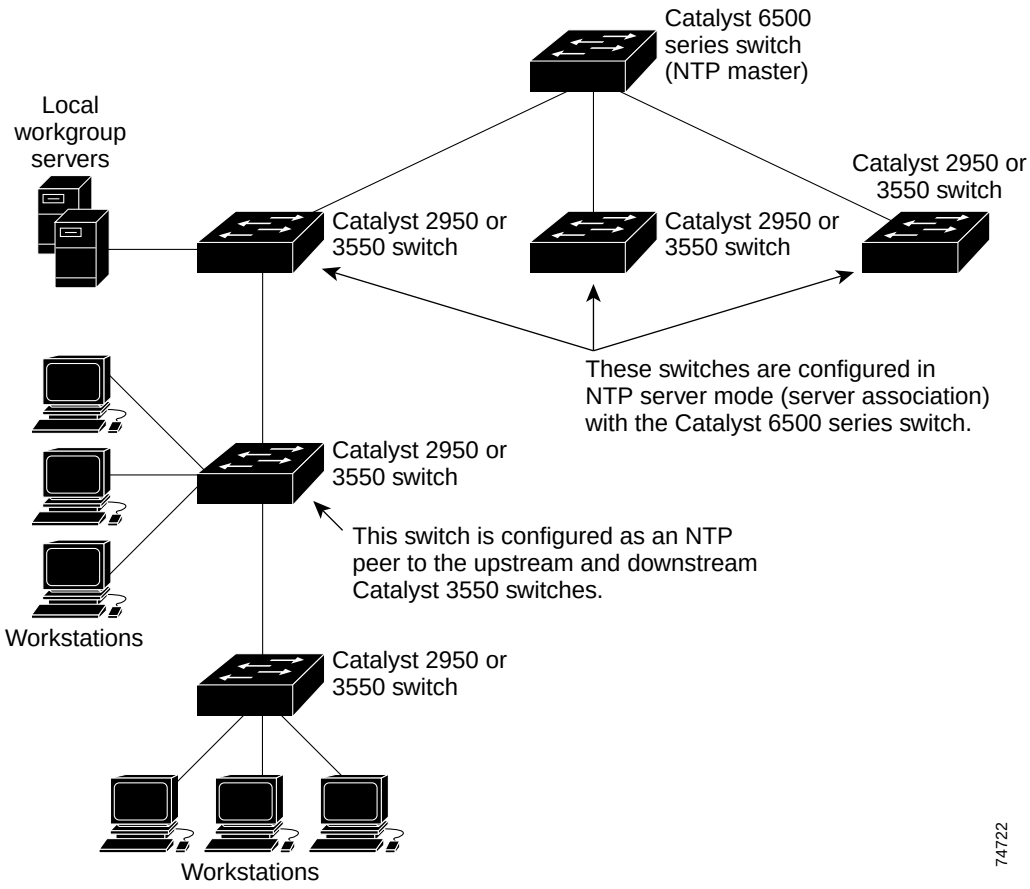
Cisco's implementation of NTP does not support stratum 1 service; it is not possible to connect to a radio or atomic clock. We recommend that the time service for your network be derived from the public NTP servers available on the IP Internet. Figure 8-1 show a typical network example using NTP.

If the network is isolated from the Internet, Cisco's implementation of NTP allows a device to act as though it is synchronized through NTP, when in fact it has determined the time by using other means. Other devices then synchronize to that device through NTP.

When multiple sources of time are available, NTP is always considered to be more authoritative. NTP time overrides the time set by any other method.

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software allows host systems to be time-synchronized as well.

Figure 8-1 Typical NTP Network Configuration



Configuring NTP

The Catalyst 2950 and 2955 switches do not have a hardware-supported clock, and they cannot function as an NTP master clock to which peers synchronize themselves when an external NTP source is not available. These switches also have no hardware support for a calendar. As a result, the **ntp update-calendar** and the **ntp master** global configuration commands are not available.

This section contains this configuration information:

- Default NTP Configuration, page 8-4
- Configuring NTP Authentication, page 8-4
- Configuring NTP Associations, page 8-5
- Configuring NTP Broadcast Service, page 8-6
- Configuring NTP Access Restrictions, page 8-7
- Configuring the Source IP Address for NTP Packets, page 8-9
- Displaying the NTP Configuration, page 8-10

Default NTP Configuration

Table 8-1 shows the default NTP configuration.

Table 8-1 Default NTP Configuration

Feature	Default Setting
NTP authentication	Disabled. No authentication key is specified.
NTP peer or server associations	None configured.
NTP broadcast service	Disabled; no interface sends or receives NTP broadcast packets.
NTP access restrictions	No access control is specified.
NTP packet source IP address	The source address is determined by the outgoing interface.

NTP is enabled on all interfaces by default. All interfaces receive NTP packets.

Configuring NTP Authentication

This procedure must be coordinated with the administrator of the NTP server; the information you configure in this procedure must be matched by the servers used by the switch to synchronize its time to the NTP server.

Beginning in privileged EXEC mode, follow these steps to authenticate the associations (communications between devices running NTP that provide for accurate timekeeping) with other devices for security purposes:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ntp authenticate**	Enable the NTP authentication feature, which is disabled by default.
Step 3	**ntp authentication-key** *number* **md5** *value*	Define the authentication keys. By default, none are defined. • For *number*, specify a key number. The range is 1 to 4294967295. • **md5** specifies that message authentication support is provided by using the message digest algorithm 5 (MD5). • For *value*, enter an arbitrary string of up to eight characters for the key. The switch does not synchronize to a device unless both have one of these authentication keys, and the key number is specified by the **ntp trusted-key** *key-number* command.
Step 4	**ntp trusted-key** *key-number*	Specify one or more key numbers (defined in Step 3) that a peer NTP device must provide in its NTP packets for this switch to synchronize to it. By default, no trusted keys are defined. For *key-number*, specify the key defined in Step 3. This command provides protection against accidentally synchronizing the switch to a device that is not trusted.

	Command	Purpose
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable NTP authentication, use the **no ntp authenticate** global configuration command. To remove an authentication key, use the **no ntp authentication-key** *number* global configuration command. To disable authentication of the identity of a device, use the **no ntp trusted-key** *key-number* global configuration command.

This example shows how to configure the switch to synchronize only to devices providing authentication key 42 in the device's NTP packets:

```
Switch(config)# ntp authenticate
Switch(config)# ntp authentication-key 42 md5 aNiceKey
Switch(config)# ntp trusted-key 42
```

Configuring NTP Associations

An NTP association can be a peer association (this switch can either synchronize to the other device or allow the other device to synchronize to it), or it can be a server association (meaning that only this switch synchronizes to the other device, and not the other way around).

Beginning in privileged EXEC mode, follow these steps to form an NTP association with another device:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ntp peer** *ip-address* [**version** *number*] [**key** *keyid*] [**source** *interface*] [**prefer**]	Configure the switch system clock to synchronize a peer or to be synchronized by a peer (peer association).
	or	or
	ntp server *ip-address* [**version** *number*] [**key** *keyid*] [**source** *interface*] [**prefer**]	Configure the switch system clock to be synchronized by a time server (server association). No peer or server associations are defined by default. • For *ip-address* in a peer association, specify either the IP address of the peer providing, or being provided, the clock synchronization. For a server association, specify the IP address of the time server providing the clock synchronization. • (Optional) For *number*, specify the NTP version number. The range is 1 to 3. By default, version 3 is selected. • (Optional) For *keyid*, enter the authentication key defined with the **ntp authentication-key** global configuration command. • (Optional) For *interface*, specify the interface from which to pick the IP source address. By default, the source IP address is taken from the outgoing interface. • (Optional) Enter the **prefer** keyword to make this peer or server the preferred one that provides synchronization. This keyword reduces switching back and forth between peers and servers.

	Command	Purpose
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

You need to configure only one end of an association; the other device can automatically establish the association. If you are using the default NTP version (version 3) and NTP synchronization does not occur, try using NTP version 2. Many NTP servers on the Internet run version 2.

To remove a peer or server association, use the **no ntp peer** *ip-address* or the **no ntp server** *ip-address* global configuration command.

This example shows how to configure the switch to synchronize its system clock with the clock of the peer at IP address 172.16.22.44 using NTP version 2:

```
Switch(config)# ntp server 172.16.22.44 version 2
```

Configuring NTP Broadcast Service

The communications between devices running NTP (known as *associations*) are usually statically configured; each device is given the IP addresses of all devices with which it should form associations. Accurate timekeeping is possible by exchanging NTP messages between each pair of devices with an association. However, in a LAN environment, NTP can be configured to use IP broadcast messages instead. This alternative reduces configuration complexity because each device can simply be configured to send or receive broadcast messages. However, the information flow is one-way only.

The switch can send or receive NTP broadcast packets on an interface-by-interface basis if there is an NTP broadcast server, such as a router, broadcasting time information on the network. The switch can send NTP broadcast packets to a peer so that the peer can synchronize to it. The switch can also receive NTP broadcast packets to synchronize its own clock. This section has procedures for both sending and receiving NTP broadcast packets.

Beginning in privileged EXEC mode, follow these steps to configure the switch to send NTP broadcast packets to peers so that they can synchronize their clock to the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the interface to send NTP broadcast packets, and enter interface configuration mode.
Step 3	**ntp broadcast** [**version** *number*] [**key** *keyid*] [*destination-address*]	Enable the interface to send NTP broadcast packets to a peer. By default, this feature is disabled on all interfaces. • (Optional) For *number*, specify the NTP version number. The range is 1 to 3. If you do not specify a version, version 3 is used. • (Optional) For *keyid*, specify the authentication key to use when sending packets to the peer. • (Optional) For *destination-address*, specify the IP address of the peer that is synchronizing its clock to this switch.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.

	Command	Purpose
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.
Step 7		Configure the connected peers to receive NTP broadcast packets as described in the next procedure.

To disable the interface from sending NTP broadcast packets, use the **no ntp broadcast** interface configuration command.

This example shows how to configure an interface to send NTP version 2 packets:

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# ntp broadcast version 2
```

Beginning in privileged EXEC mode, follow these steps to configure the switch to receive NTP broadcast packets from connected peers:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the interface to receive NTP broadcast packets, and enter interface configuration mode.
Step 3	**ntp broadcast client**	Enable the interface to receive NTP broadcast packets. By default, no interfaces receive NTP broadcast packets.
Step 4	**exit**	Return to global configuration mode.
Step 5	**ntp broadcastdelay** *microseconds*	(Optional) Change the estimated round-trip delay between the switch and the NTP broadcast server. The default is 3000 microseconds; the range is 1 to 999999.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable an interface from receiving NTP broadcast packets, use the **no ntp broadcast client** interface configuration command. To change the estimated round-trip delay to the default, use the **no ntp broadcastdelay** global configuration command.

This example shows how to configure an interface to receive NTP broadcast packets:

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# ntp broadcast client
```

Configuring NTP Access Restrictions

You can control NTP access on two levels as described in these sections:

- Creating an Access Group and Assigning a Basic IP Access List, page 8-8
- Disabling NTP Services on a Specific Interface, page 8-9

Creating an Access Group and Assigning a Basic IP Access List

Beginning in privileged EXEC mode, follow these steps to control access to NTP services by using access lists:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ntp access-group** {**query-only** | **serve-only** | **serve** | **peer**} *access-list-number*	Create an access group, and apply a basic IP access list. The keywords have these meanings: • **query-only**—Allows only NTP control queries. • **serve-only**—Allows only time requests. • **serve**—Allows time requests and NTP control queries, but does not allow the switch to synchronize to the remote device. • **peer**—Allows time requests and NTP control queries and allows the switch to synchronize to the remote device. For *access-list-number*, enter a standard IP access list number from 1 to 99.
Step 3	**access-list** *access-list-number* **permit** *source* [*source-wildcard*]	Create the access list. • For *access-list-number*, enter the number specified in Step 2. • Enter the **permit** keyword to permit access if the conditions are matched. • For *source*, enter the IP address of the device that is permitted access to the switch. • (Optional) For *source-wildcard*, enter the wildcard bits to be applied to the source. **Note** When creating an access list, remember that, by default, the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The access group keywords are scanned in this order, from least restrictive to most restrictive:

1. **peer**—Allows time requests and NTP control queries and allows the switch to synchronize itself to a device whose address passes the access list criteria.
2. **serve**—Allows time requests and NTP control queries, but does not allow the switch to synchronize itself to a device whose address passes the access list criteria.
3. **serve-only**—Allows only time requests from a device whose address passes the access list criteria.
4. **query-only**—Allows only NTP control queries from a device whose address passes the access list criteria.

If the source IP address matches the access lists for more than one access type, the first type is granted. If no access groups are specified, all access types are granted to all devices. If any access groups are specified, only the specified access types are granted.

To remove access control to the switch NTP services, use the **no ntp access-group** {**query-only** | **serve-only** | **serve** | **peer**} global configuration command.

This example shows how to configure the switch to allow itself to synchronize to a peer from access list 99. However, the switch restricts access to allow only time requests from access list 42:

```
Switch# configure terminal
Switch(config)# ntp access-group peer 99
Switch(config)# ntp access-group serve-only 42
Switch(config)# access-list 99 permit 172.20.130.5
Switch(config)# access list 42 permit 172.20.130.6
```

Disabling NTP Services on a Specific Interface

NTP services are enabled on all interfaces by default.

Beginning in privileged EXEC mode, follow these steps to disable NTP packets from being received on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to disable.
Step 3	**ntp disable**	Disable NTP packets from being received on the interface. By default, all interfaces receive NTP packets.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To re-enable receipt of NTP packets on an interface, use the **no ntp disable** interface configuration command.

Configuring the Source IP Address for NTP Packets

When the switch sends an NTP packet, the source IP address is normally set to the address of the interface through which the NTP packet is sent. Use the **ntp source** global configuration command when you want to use a particular source IP address for all NTP packets. The address is taken from the specified interface. This command is useful if the address on an interface cannot be used as the destination for reply packets.

Beginning in privileged EXEC mode, follow these steps to configure a specific interface from which the IP source address is to be taken:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ntp source** *type number*	Specify the interface type and number from which the IP source address is taken. By default, the source address is determined by the outgoing interface.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The specified interface is used for the source address for all packets sent to all destinations. If a source address is to be used for a specific association, use the **source** keyword in the **ntp peer** or **ntp server** global configuration command as described in the "Configuring NTP Associations" section on page 8-5.

Displaying the NTP Configuration

You can use two privileged EXEC commands to display NTP information:

- **show ntp associations** [**detail**]
- **show ntp status**

For detailed information about the fields in these displays, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

Configuring Time and Date Manually

If no other source of time is available, you can manually configure the time and date after the system is restarted. The time remains accurate until the next system restart. We recommend that you use manual configuration only as a last resort. If you have an outside source to which the switch can synchronize, you do not need to manually set the system clock.

This section contains this configuration information:

- Setting the System Clock, page 8-11
- Displaying the Time and Date Configuration, page 8-11
- Configuring the Time Zone, page 8-12
- Configuring Summer Time (Daylight Saving Time), page 8-13

Setting the System Clock

If you have an outside source on the network that provides time services, such as an NTP server, you do not need to manually set the system clock.

Beginning in privileged EXEC mode, follow these steps to set the system clock:

	Command	Purpose
Step 1	**clock set** *hh*:*mm*:*ss day month year* or **clock set** *hh*:*mm*:*ss month day year*	Manually set the system clock using one of these formats. • For *hh*:*mm*:*ss*, specify the time in hours (24-hour format), minutes, and seconds. The time specified is relative to the configured time zone. • For *day*, specify the day by date in the month. • For *month*, specify the month by name. • For *year*, specify the year (no abbreviation).
Step 2	**show running-config**	Verify your entries.
Step 3	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to manually set the system clock to 1:32 p.m. on July 23, 2001:

```
Switch# clock set 13:32:00 23 July 2001
```

Displaying the Time and Date Configuration

To display the time and date configuration, use the **show clock** [**detail**] privileged EXEC command.

The system clock keeps an *authoritative* flag that shows whether the time is authoritative (believed to be accurate). If the system clock has been set by a timing source such as NTP, the flag is set. If the time is not authoritative, it is used only for display purposes. Until the clock is authoritative and the *authoritative* flag is set, the flag prevents peers from synchronizing to the clock when the peers' time is invalid.

The symbol that precedes the **show clock** display has this meaning:

- *—Time is not authoritative.
- (blank)—Time is authoritative.
- .—Time is authoritative, but NTP is not synchronized.

Configuring the Time Zone

Beginning in privileged EXEC mode, follow these steps to manually configure the time zone:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**clock timezone** *zone hours-offset* [*minutes-offset*]	Set the time zone. The switch keeps internal time in universal time coordinated (UTC), so this command is used only for display purposes and when the time is manually set. • For *zone*, enter the name of the time zone to be displayed when standard time is in effect. The default is UTC. • For *hours-offset*, enter the hours offset from UTC. • (Optional) For *minutes-offset*, enter the minutes offset from UTC.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The *minutes-offset* variable in the **clock timezone** global configuration command is available for those cases where a local time zone is a percentage of an hour different from UTC. For example, the time zone for some sections of Atlantic Canada (AST) is UTC-3.5, where the 3 means 3 hours and .5 means 50 percent. In this case, the necessary command is **clock timezone AST -3 30**.

To set the time to UTC, use the **no clock timezone** global configuration command.

Configuring Summer Time (Daylight Saving Time)

Beginning in privileged EXEC mode, follow these steps to configure summer time (daylight saving time) in areas where it starts and ends on a particular day of the week each year:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**clock summer-time** *zone* **recurring** [*week day month hh*:*mm week day month hh*:*mm* [*offset*]]	Configure summer time to start and end on the specified days every year. Summer time is disabled by default. If you specify **clock summer-time** *zone* **recurring** without parameters, the summer time rules default to the United States rules. • For *zone*, specify the name of the time zone (for example, PDT) to be displayed when summer time is in effect. • (Optional) For *week*, specify the week of the month (1 to 5 or **last**). • (Optional) For *day*, specify the day of the week (Sunday, Monday...). • (Optional) For *month*, specify the month (January, February...). • (Optional) For *hh*:*mm*, specify the time (24-hour format) in hours and minutes. • (Optional) For *offset*, specify the number of minutes to add during summer time. The default is 60.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The first part of the **clock summer-time** global configuration command specifies when summer time begins, and the second part specifies when it ends. All times are relative to the local time zone. The start time is relative to standard time. The end time is relative to summer time. If the starting month is after the ending month, the system assumes that you are in the southern hemisphere.

This example shows how to specify that summer time starts on the first Sunday in April at 02:00 and ends on the last Sunday in October at 02:00:

```
Switch(config)# clock summer-time PDT recurring 1 Sunday April 2:00 last Sunday October
2:00
```

Beginning in privileged EXEC mode, follow these steps if summer time in your area does not follow a recurring pattern (configure the exact date and time of the next summer time events):

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**clock summer-time** *zone* **date** [*month date year hh*:*mm month date year hh*:*mm* [*offset*]] or **clock summer-time** *zone* **date** [*date month year hh*:*mm date month year hh*:*mm* [*offset*]]	Configure summer time to start on the first date and end on the second date. Summer time is disabled by default. • For *zone*, specify the name of the time zone (for example, PDT) to be displayed when summer time is in effect. • (Optional) For *week*, specify the week of the month (1 to 5 or **last**). • (Optional) For *day*, specify the day of the week (Sunday, Monday...). • (Optional) For *month*, specify the month (January, February...). • (Optional) For *hh*:*mm*, specify the time (24-hour format) in hours and minutes. • (Optional) For *offset*, specify the number of minutes to add during summer time. The default is 60.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The first part of the **clock summer-time** global configuration command specifies when summer time begins, and the second part specifies when it ends. All times are relative to the local time zone. The start time is relative to standard time. The end time is relative to summer time. If the starting month is after the ending month, the system assumes that you are in the southern hemisphere.

To disable summer time, use the **no clock summer-time** global configuration command.

This example shows how to set summer time to start on October 12, 2000, at 02:00, and end on April 26, 2001, at 02:00:

```
Switch(config)# clock summer-time pdt date 12 October 2000 2:00 26 April 2001 2:00
```

Configuring a System Name and Prompt

You configure the system name on the switch to identify it. By default, the system name and prompt are *Switch*.

If you have not configured a system prompt, the first 20 characters of the system name are used as the system prompt. A greater-than symbol [>] is appended. The prompt is updated whenever the system name changes, unless you manually configure the prompt by using the **prompt** global configuration command.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco IOS Configuration Fundamentals Command Reference* and the *Cisco IOS IP and IP Routing Command Reference for Release 12.1*.

This section contains this configuration information:

- Default System Name and Prompt Configuration, page 8-15
- Configuring a System Name, page 8-15
- Configuring a System Prompt, page 8-16
- Understanding DNS, page 8-16

Default System Name and Prompt Configuration

The default switch system name and prompt is *Switch*.

Configuring a System Name

Beginning in privileged EXEC mode, follow these steps to manually configure a system name:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**hostname** *name*	Manually configure a system name. The default setting is *switch*. The name must follow the rules for ARPANET host names. They must start with a letter, end with a letter or digit, and have as interior characters only letters, digits, and hyphens. Names can be up to 63 characters.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

When you set the system name, it is also used as the system prompt. You can override the prompt setting by using the **prompt** global configuration command.

To return to the default hostname, use the **no hostname** global configuration command.

Configuring a System Prompt

Beginning in privileged EXEC mode, follow these steps to manually configure a system prompt:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**prompt** *string*	Configure the command-line prompt to override the setting from the **hostname** command. The default prompt is either *switch* or the name defined with the **hostname** global configuration command, followed by an angle bracket (>) for user EXEC mode or a pound sign (#) for privileged EXEC mode. The prompt can consist of all printing characters and escape sequences.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default prompt, use the **no prompt** [*string*] global configuration command.

Understanding DNS

The DNS protocol controls the Domain Name System (DNS), a distributed database with which you can map host names to IP addresses. When you configure DNS on your switch, you can substitute the host name for the IP address with all IP commands, such as **ping**, **telnet**, **connect**, and related Telnet support operations.

IP defines a hierarchical naming scheme that allows a device to be identified by its location or domain. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco Systems is a commercial organization that IP identifies by a *com* domain name, so its domain name is *cisco.com*. A specific device in this domain, for example, the File Transfer Protocol (FTP) system is identified as *ftp.cisco.com*.

To keep track of domain names, IP has defined the concept of a domain name server, which holds a cache (or database) of names mapped to IP addresses. To map domain names to IP addresses, you must first identify the host names, specify the name server that is present on your network, and enable the DNS.

This section contains this configuration information:

- Default DNS Configuration, page 8-17
- Setting Up DNS, page 8-17
- Displaying the DNS Configuration, page 8-18

Default DNS Configuration

Table 8-2 shows the default DNS configuration.

Table 8-2 Default DNS Configuration

Feature	Default Setting
DNS enable state	Enabled.
DNS default domain name	None configured.
DNS servers	No name server addresses are configured.

Setting Up DNS

Beginning in privileged EXEC mode, follow these steps to set up your switch to use the DNS:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip domain-name** *name*	Define a default domain name that the software uses to complete unqualified host names (names without a dotted-decimal domain name). Do not include the initial period that separates an unqualified name from the domain name. At boot time, no domain name is configured; however, if the switch configuration comes from a BOOTP or Dynamic Host Configuration Protocol (DHCP) server, then the default domain name might be set by the BOOTP or DHCP server (if the servers were configured with this information).
Step 3	**ip name-server** *server-address1* [*server-address2 ... server-address6*]	Specify the address of one or more name servers to use for name and address resolution. You can specify up to six name servers. Separate each server address with a space. The first server specified is the primary server. The switch sends DNS queries to the primary server first. If that query fails, the backup servers are queried.
Step 4	**ip domain-lookup**	(Optional) Enable DNS-based host name-to-address translation on your switch. This feature is enabled by default. If your network devices require connectivity with devices in networks for which you do not control name assignment, you can dynamically assign device names that uniquely identify your devices by using the global Internet naming scheme (DNS).
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

If you use the switch IP address as its hostname, the IP address is used and no DNS query occurs. If you configure a hostname that contains no periods (.), a period followed by the default domain name is appended to the hostname before the DNS query is made to map the name to an IP address. The default

domain name is the value set by the **ip domain-name** global configuration command. If there is a period (.) in the hostname, the IOS software looks up the IP address without appending any default domain name to the hostname.

To remove a domain name, use the **no ip domain-name** *name* global configuration command. To remove a name server address, use the **no ip name-server** *server-address* global configuration command. To disable DNS on the switch, use the **no ip domain-lookup** global configuration command.

Displaying the DNS Configuration

To display the DNS configuration information, use the **show running-config** privileged EXEC command.

Creating a Banner

You can configure a message-of-the-day (MOTD) and a login banner. The MOTD banner displays on all connected terminals at login and is useful for sending messages that affect all network users (such as impending system shutdowns).

The login banner also displays on all connected terminals. It is displayed after the MOTD banner and before the login prompts.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

This section contains this configuration information:

- Default Banner Configuration, page 8-18
- Configuring a Message-of-the-Day Login Banner, page 8-19
- Configuring a Login Banner, page 8-20

Default Banner Configuration

The MOTD and login banners are not configured.

Configuring a Message-of-the-Day Login Banner

You can create a single or multiline message banner that appears on the screen when someone logs in to the switch.

Beginning in privileged EXEC mode, follow these steps to configure a MOTD login banner:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**banner motd** *c message c*	Specify the message of the day. For *c*, enter the delimiting character of your choice, for example, a pound sign (#), and press the **Return** key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded. For *message*, enter a banner message up to 255 characters. You cannot use the delimiting character in the message.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete the MOTD banner, use the **no banner motd** global configuration command.

This example shows how to configure a MOTD banner for the switch by using the pound sign (#) symbol as the beginning and ending delimiter:

```
Switch(config)# banner motd #
This is a secure site. Only authorized users are allowed.
For access, contact technical support.
#
Switch(config)#
```

This example shows the banner displayed from the previous configuration:

```
Unix> telnet 172.2.5.4
Trying 172.2.5.4...
Connected to 172.2.5.4.
Escape character is '^]'.

This is a secure site. Only authorized users are allowed.
For access, contact technical support.

User Access Verification

Password:
```

Configuring a Login Banner

You can configure a login banner to be displayed on all connected terminals. This banner appears after the MOTD banner and before the login prompt.

Beginning in privileged EXEC mode, follow these steps to configure a login banner:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**banner login** *c message c*	Specify the login message. For *c*, enter the delimiting character of your choice, for example, a pound sign (#), and press the **Return** key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded. For *message*, enter a login message up to 255 characters. You cannot use the delimiting character in the message.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete the login banner, use the **no banner login** global configuration command.

This example shows how to configure a login banner for the switch by using the dollar sign ($) symbol as the beginning and ending delimiter:

```
Switch(config)# banner login $
Access for authorized users only. Please enter your username and password.
$
Switch(config)#
```

Managing the MAC Address Table

The MAC address table contains address information that the switch uses to forward traffic between ports. All MAC addresses in the address table are associated with one or more ports. The address table includes these types of addresses:

- Dynamic address: a source MAC address that the switch learns and then ages when it is not in use.
- Static address: a manually entered unicast or multicast address that does not age and that is not lost when the switch resets.

The address table lists the destination MAC address, the associated VLAN ID, and port number associated with the address.

Note For complete syntax and usage information for the commands used in this section, refer to the command reference for this release.

This section contains this configuration information:

- Building the Address Table, page 8-21
- MAC Addresses and VLANs, page 8-21
- Default MAC Address Table Configuration, page 8-22
- Changing the Address Aging Time, page 8-22
- Removing Dynamic Address Entries, page 8-23
- Configuring MAC Address Notification Traps, page 8-23
- Adding and Removing Static Address Entries, page 8-25
- Adding and Removing Secure Addresses, page 8-26
- Displaying Address Table Entries, page 8-26

Building the Address Table

With multiple MAC addresses supported on all ports, you can connect any port on the switch to individual workstations, repeaters, switches, routers, or other network devices. The switch provides dynamic addressing by learning the source address of packets it receives on each port and adding the address and its associated port number to the address table. As stations are added or removed from the network, the switch updates the address table, adding new dynamic addresses and aging out those that are not in use.

The aging interval is configured on a per-switch basis. However, the switch maintains an address table for each VLAN, and STP can accelerate the aging interval on a per-VLAN basis.

The switch sends packets between any combination of ports, based on the destination address of the received packet. Using the MAC address table, the switch forwards the packet only to the port or ports associated with the destination address. If the destination address is on the port that sent the packet, the packet is filtered and not forwarded. The switch always uses the store-and-forward method: complete packets are stored and checked for errors before transmission.

MAC Addresses and VLANs

All addresses are associated with a VLAN. An address can exist in more than one VLAN and have different destinations in each. Multicast addresses, for example, could be forwarded to port 1 in VLAN 1 and ports 9, 10, and 11 in VLAN 5.

Each VLAN maintains its own logical address table. A known address in one VLAN is unknown in another until it is learned or statically associated with a port in the other VLAN. Addresses that are statically entered in one VLAN must be configured as static addresses in all other VLANs or remain unlearned in the other VLANs.

Default MAC Address Table Configuration

Table 8-3 shows the default MAC address table configuration.

Table 8-3 Default MAC Address Table Configuration

Feature	Default Setting
Aging time	300 seconds
Dynamic addresses	Automatically learned
Static addresses	None configured

Changing the Address Aging Time

Dynamic addresses are source MAC addresses that the switch learns and then ages when they are not in use. You can change the aging time setting for all VLANs or for a specified VLAN.

Setting too short an aging time can cause addresses to be prematurely removed from the table. Then when the switch receives a packet for an unknown destination, it floods the packet to all ports in the same VLAN as the receiving port. This unnecessary flooding can impact performance. Setting too long an aging time can cause the address table to be filled with unused addresses, which prevents new addresses from being learned. Flooding results, which can impact switch performance.

Beginning in privileged EXEC mode, follow these steps to configure the dynamic address table aging time:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mac address-table aging-time** [**0** | *10-1000000*] [**vlan** *vlan-id*]	Set the length of time that a dynamic entry remains in the MAC address table after the entry is used or updated. The range is 10 to 1000000 seconds. The default is 300. You can also enter 0, which disables aging. Static address entries are never aged or removed from the table. For *vlan-id*, valid IDs are 1 to 4094 when the enhanced software image (EI) is installed and 1 to 1005 when the standard software image (SI) is installed.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show mac address-table aging-time**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default value, use the **no mac address-table aging-time** global configuration command.

Removing Dynamic Address Entries

To remove all dynamic entries, use the **clear mac address-table dynamic** command in privileged EXEC mode. You can also remove a specific MAC address (**clear mac address-table dynamic address** *mac-address*), remove all addresses on the specified physical port or port channel (**clear mac address-table dynamic interface** *interface-id*), or remove all addresses on a specified VLAN (**clear mac address-table dynamic vlan** *vlan-id*).

To verify that dynamic entries have been removed, use the **show mac address-table dynamic** privileged EXEC command.

Configuring MAC Address Notification Traps

MAC address notification enables you to track users on a network by storing the MAC address activity on the switch. Whenever the switch learns or removes a MAC address, an SNMP notification can be generated and sent to the NMS. If you have many users coming and going from the network, you can set a trap interval time to bundle the notification traps and reduce network traffic. The MAC notification history table stores the MAC address activity for each hardware port for which the trap is enabled. MAC address notifications are generated for dynamic and secure MAC addresses; events are not generated for self addresses, multicast addresses, or other static addresses.

Beginning in privileged EXEC mode, follow these steps to configure the switch to send MAC address notification traps to an NMS host:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server host** *host-addr* {**traps** | **informs**} {**version** {**1** | **2c** | **3**}} *community-string notification-type*	Specify the recipient of the trap message. • For *host-addr*, specify the name or address of the NMS. • Specify **traps** (the default) to send SNMP traps to the host. Specify **informs** to send SNMP informs to the host. • Specify the SNMP version to support. Version 1, the default, is not available with informs. • For *community-string*, specify the string to send with the notification operation. Though you can set this string by using the **snmp-server host** command, we recommend that you define this string by using the **snmp-server community** command before using the **snmp-server host** command. • For *notification-type*, use the **mac-notification** keyword.
Step 3	**snmp-server enable traps mac-notification**	Enable the switch to send MAC address traps to the NMS.
Step 4	**mac address-table notification**	Enable the MAC address notification feature.

	Command	Purpose
Step 5	**mac address-table notification** [**interval** *value*] | [**history-size** *value*]	Enter the trap interval time and the history table size. • (Optional) For **interval** *value*, specify the notification trap interval in seconds between each set of traps that are generated to the NMS. The range is 0 to 2147483647 seconds; the default is 1 second. • (Optional) For **history-size** *value*, specify the maximum number of entries in the MAC notification history table. The range is 0 to 500; the default is 1.
Step 6	**interface** *interface-id*	Enter interface configuration mode, and specify the interface on which to enable the SNMP MAC address notification trap.
Step 7	**snmp trap mac-notification** {**added** | **removed**}	Enable the MAC address notification trap. • Enable the MAC notification trap whenever a MAC address is **added** on this interface. • Enable the MAC notification trap whenever a MAC address is **removed** from this interface.
Step 8	**end**	Return to privileged EXEC mode.
Step 9	**show mac address-table notification interface** **show running-config**	Verify your entries.
Step 10	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable the switch from sending MAC address notification traps, use the **no snmp-server enable traps mac-notification** global configuration command. To disable the MAC address notification traps on a specific interface, use the **no snmp trap mac-notification** {**added** | **removed**} interface configuration command. To disable the MAC address notification feature, use the **no mac address-table notification** global configuration command.

This example shows how to specify 172.20.10.10 as the NMS, enable the switch to send MAC address notification traps to the NMS, enable the MAC address notification feature, set the interval time to 60 seconds, set the history-size to 100 entries, and enable traps whenever a MAC address is added on Fast Ethernet interface 0/4.

```
Switch(config)# snmp-server host 172.20.10.10 traps private
Switch(config)# snmp-server enable traps mac-notification
Switch(config)# mac address-table notification
Switch(config)# mac address-table notification interval 60
Switch(config)# mac address-table notification history-size 100
Switch(config)# interface fastethernet0/4
Switch(config-if)# snmp trap mac-notification added
```

You can verify the previous commands by entering the **show mac address-table notification interface** and the **show mac address-table notification** privileged EXEC commands.

Adding and Removing Static Address Entries

A static address has these characteristics:

- It is manually entered in the address table and must be manually removed.
- It can be a unicast or multicast address.
- It does not age and is retained when the switch restarts.

You can add and remove static addresses and define the forwarding behavior for them. The forwarding behavior determines how a port that receives a packet forwards it to another port for transmission. Because all ports are associated with at least one VLAN, the switch acquires the VLAN ID for the address from the ports that you specify. You can specify a different list of destination ports for each source port.

A static address in one VLAN must be a static address in other VLANs. A packet with a static address that arrives on a VLAN where it has not been statically entered is flooded to all ports and not learned.

You add a static address to the address table by specifying the destination MAC address (unicast or multicast) and the VLAN from which it is received. Packets received with this destination address are forwarded to the interface specified with the *interface-id* option.

Beginning in privileged EXEC mode, follow these steps to add a static address:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mac address-table static** *mac-addr* **vlan** *vlan-id* **interface** *interface-id*	Add a static address to the MAC address table. • For *mac-addr*, specify the destination MAC address (unicast or multicast) to add to the address table. Packets with this destination address received in the specified VLAN are forwarded to the specified interface. • For *vlan-id*, specify the VLAN for which the packet with the specified MAC address is received. Valid VLAN IDs are 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • For *interface-id...*, specify the interface to which the received packet is forwarded. Valid interfaces include physical ports.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show mac address-table static**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove static entries from the address table, use the **no mac address-table static** *mac-addr* **vlan** *vlan-id* **interface** *interface-id* global configuration command.

This example shows how to add the static address c2f3.220a.12f4 to the MAC address table. When a packet is received in VLAN 4 with this MAC address as its destination address, the packets is forwarded to the specified interface:

```
Switch(config)# mac address-table static c2f3.220a.12f4 vlan 4 interface
gigabitethernet0/1
```

Adding and Removing Secure Addresses

A secure address is a manually entered unicast address or dynamically learned address that is forwarded to only one port per VLAN. If you enter a static address that is already assigned to another port, the request will be rejected.

Secure addresses can be learned dynamically if the configured secure addresses do not reach the maximum limit of the port.

You can configure an interface to convert the dynamic MAC addresses to *sticky* secure MAC addresses and to add them to the running configuration by enabling *sticky learning*. When sticky learning is enabled, the interface converts all the dynamic secure MAC addresses, including those that were learned dynamically before sticky learning is enabled, to sticky secure MAC addresses. It adds all the sticky secure MAC addresses to the running configuration. For more information, see the "Secure MAC Addresses" section on page 19-4.

Beginning in privileged EXEC mode, follow these steps to add a secure address:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify an interface, and enter interface configuration mode.
Step 3	**switchport port-security mac-address** *mac-address*	Add a secure address.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show port-security**	Verify your entry.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a secure address, use the **no switchport port-security mac-address** *mac-address* global configuration command.

Displaying Address Table Entries

You can display the MAC address table by using one or more of the privileged EXEC commands described in Table 8-4:

Table 8-4 Commands for Displaying the MAC Address Table

Command	Description
show mac address-table address	Displays MAC address table information for the specified MAC address.
show mac address-table aging-time	Displays the aging time in all VLANs or the specified VLAN.
show mac address-table count	Displays the number of addresses present in all VLANs or the specified VLAN.
show mac address-table dynamic	Displays dynamic MAC address table entries only.
show mac address-table interface	Displays the MAC address table information for the specified interface.
show mac address-table multicast	Displays the Layer 2 multicast entries for all VLANs or the specified VLAN.
show mac address-table static	Displays static MAC address table entries only.
show mac address-table vlan	Displays the MAC address table information for the specified VLAN.

Managing the ARP Table

To communicate with a device (over Ethernet, for example), the software first must determine the 48-bit MAC or the local data link address of that device. The process of determining the local data link address from an IP address is called *address resolution*.

The Address Resolution Protocol (ARP) associates a host IP address with the corresponding media or MAC addresses and the VLAN ID. Taking an IP address as input, ARP determines the associated MAC address. Once a MAC address is determined, the IP-MAC address association is stored in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests and replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP). By default, standard Ethernet-style ARP encapsulation (represented by the **arpa** keyword) is enabled on the IP interface.

ARP entries added manually to the table do not age and must be manually removed.

For CLI procedures, refer to the Cisco IOS Release 12.1 documentation on Cisco.com.

Configuring Switch-Based Authentication

This chapter describes how to configure switch-based authentication on the Catalyst 2950 or Catalyst 2955 switch. This chapter consists of these sections:

- Preventing Unauthorized Access to Your Switch, page 9-1
- Protecting Access to Privileged EXEC Commands, page 9-2
- Controlling Switch Access with TACACS+, page 9-9
- Controlling Switch Access with RADIUS, page 9-17
- Configuring the Switch for Local Authentication and Authorization, page 9-30
- Configuring the Switch for Secure Shell, page 9-31

Preventing Unauthorized Access to Your Switch

You can prevent unauthorized users from reconfiguring your switch and viewing configuration information. Typically, you want network administrators to have access to your switch while you restrict access to users who dial from outside the network through an asynchronous port, connect from outside the network through a serial port, or connect through a terminal or workstation from within the local network.

To prevent unauthorized access into your switch, you should configure one or more of these security features:

- At a minimum, you should configure passwords and privileges at each switch port. These passwords are locally stored on the switch. When users attempt to access the switch through a port or line, they must enter the password specified for the port or line before they can access the switch. For more information, see the "Protecting Access to Privileged EXEC Commands" section on page 9-2.
- For an additional layer of security, you can also configure username and password pairs, which are locally stored on the switch. These pairs are assigned to lines or interfaces and authenticate each user before that user can access the switch. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair. For more information, see the "Configuring Username and Password Pairs" section on page 9-6.
- If you want to use username and password pairs, but you want to store them centrally on a server instead of locally, you can store them in a database on a security server. Multiple networking devices can then use the same database to obtain user authentication (and, if necessary, authorization) information. For more information, see the "Controlling Switch Access with TACACS+" section on page 9-9.

Protecting Access to Privileged EXEC Commands

A simple way of providing terminal access control in your network is to use passwords and assign privilege levels. Password protection restricts access to a network or network device. Privilege levels define what commands users can enter after they have logged into a network device.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco IOS Security Command Reference for Release 12.1*.

This section describes how to control access to the configuration file and privileged EXEC commands. It contains this configuration information:

- Default Password and Privilege Level Configuration, page 9-2
- Setting or Changing a Static Enable Password, page 9-3
- Protecting Enable and Enable Secret Passwords with Encryption, page 9-4
- Setting a Telnet Password for a Terminal Line, page 9-5
- Configuring Username and Password Pairs, page 9-6
- Configuring Multiple Privilege Levels, page 9-7

Default Password and Privilege Level Configuration

Table 9-1 shows the default password and privilege level configuration.

Table 9-1 Default Password and Privilege Levels

Feature	Default Setting
Enable password and privilege level	No password is defined. The default is level 15 (privileged EXEC level). The password is not encrypted in the configuration file.
Enable secret password and privilege level	No password is defined. The default is level 15 (privileged EXEC level). The password is encrypted before it is written to the configuration file.
Line password	No password is defined.

Setting or Changing a Static Enable Password

The enable password controls access to the privileged EXEC mode. Beginning in privileged EXEC mode, follow these steps to set or change a static enable password:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**enable password** *password*	Define a new password or change an existing password for access to privileged EXEC mode. By default, no password is defined. For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. It can contain the question mark (?) character if you precede the question mark with the key combination Crtl-v when you create the password; for example, to create the password abc?123, do this: Enter **abc**. Enter **Crtl-v**. Enter **?123**. When the system prompts you to enter the enable password, you need not precede the question mark with the Ctrl-v; you can simply enter abc?123 at the password prompt.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file. The enable password is not encrypted and can be read in the switch configuration file.

To remove the password, use the **no enable password** global configuration command.

This example shows how to change the enable password to *l1u2c3k4y5*. The password is not encrypted and provides access to level 15 (traditional privileged EXEC mode access):

```
Switch(config)# enable password l1u2c3k4y5
```

Protecting Enable and Enable Secret Passwords with Encryption

To provide an additional layer of security, particularly for passwords that cross the network or that are stored on a Trivial File Transfer Protocol (TFTP) server, you can use either the **enable password** or **enable secret** global configuration commands. Both commands accomplish the same thing; that is, you can establish an encrypted password that users must enter to access privileged EXEC mode (the default) or any privilege level you specify.

We recommend that you use the **enable secret** command because it uses an improved encryption algorithm.

If you configure the **enable secret** command, it takes precedence over the **enable password** command; the two commands cannot be in effect simultaneously.

Beginning in privileged EXEC mode, follow these steps to configure encryption for enable and enable secret passwords:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**enable password** [**level** *level*] {*password* | *encryption-type encrypted-password*}	Define a new password or change an existing password for access to privileged EXEC mode.
	or	or
	enable secret [**level** *level*] {*password* | *encryption-type encrypted-password*}	Define a secret password, which is saved using a nonreversible encryption method. • (Optional) For *level*, the range is from 0 to 15. Level 1 is normal user EXEC mode privileges. The default level is 15 (privileged EXEC mode privileges). • For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined. • (Optional) For *encryption-type*, only type 5, a Cisco proprietary encryption algorithm, is available. If you specify an encryption type, you must provide an encrypted password—an encrypted password you copy from another Catalyst2950 switch configuration. **Note** If you specify an encryption type and then enter a clear text password, you can not re-enter privileged EXEC mode. You cannot recover a lost encrypted password by any method.
Step 3	**service password-encryption**	(Optional) Encrypt the password when the password is defined or when the configuration is written. Encryption prevents the password from being readable in the configuration file.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

If both the enable and enable secret passwords are defined, users must enter the enable secret password.

Use the **level** keyword to define a password for a specific privilege level. After you specify the level and set a password, give the password only to users who need to have access at this level. Use the **privilege level** global configuration command to specify commands accessible at various levels. For more information, see the "Configuring Multiple Privilege Levels" section on page 9-7.

If you enable password encryption, it applies to all passwords including username passwords, authentication key passwords, the privileged command password, and console and virtual terminal line passwords.

To remove a password and level, use the **no enable password** [**level** *level*] or **no enable secret** [**level** *level*] global configuration command. To disable password encryption, use the **no service password-encryption** global configuration command.

This example shows how to configure the encrypted password *1FaD0$Xyti5Rkls3LoyxzS8* for privilege level 2:

```
Switch(config)# enable secret level 2 5 $1$FaD0$Xyti5Rkls3LoyxzS8
```

Setting a Telnet Password for a Terminal Line

When you power-up your switch for the first time, an automatic setup program runs to assign IP information and to create a default configuration for continued use. The setup program also prompts you to configure your switch for Telnet access through a password. If you neglected to configure this password during the setup program, you can configure it now through the command-line interface (CLI).

Beginning in privileged EXEC mode, follow these steps to configure your switch for Telnet access:

	Command	Purpose
Step 1		Attach a PC or workstation with emulation software to the switch console port. The default data characteristics of the console port are 9600, 8, 1, no parity. You might need to press the Return key several times to see the command-line prompt.
Step 2	**enable password** *password*	Enter privileged EXEC mode.
Step 3	**configure terminal**	Enter global configuration mode.
Step 4	**line vty 0 15**	Configure the number of Telnet sessions (lines), and enter line configuration mode. There are 16 possible sessions on a command-capable switch. The 0 and 15 mean that you are configuring all 16 possible Telnet sessions.
Step 5	**password** *password*	Enter a Telnet password for the line or lines. For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries. The password is listed under the command **line vty 0 15**.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the password, use the **no password** global configuration command.

This example shows how to set the Telnet password to *let45me67in89*:

```
Switch(config)# line vty 10
Switch(config-line)# password let45me67in89
```

Configuring Username and Password Pairs

You can configure username and password pairs, which are locally stored on the switch. These pairs are assigned to lines or interfaces and authenticate each user before that user can access the switch. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair.

Beginning in privileged EXEC mode, follow these steps to establish a username-based authentication system that requests a login username and a password:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**username** *name* [**privilege** *level*] {**password** *encryption-type password*}	Enter the username, privilege level, and password for each user. • For *name*, specify the user ID as one word. Spaces and quotation marks are not allowed. • (Optional) For *level*, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 1 gives user EXEC mode access. • For *encryption-type*, enter 0 to specify that an unencrypted password will follow. Enter 7 to specify that a hidden password will follow. • For *password*, specify the password the user must enter to gain access to the switch. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the **username** command.
Step 3	**line console 0** or **line vty 0 15**	Enter line configuration mode, and configure the console port (line 0) or the VTY lines (line 0 to 15).
Step 4	**login local**	Enable local password checking at login time. Authentication is based on the username specified in Step 2.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable username authentication for a specific user, use the **no username** *name* global configuration command. To disable password checking and allow connections without a password, use the **no login** line configuration command.

Configuring Multiple Privilege Levels

By default, the IOS software has two modes of password security: user EXEC and privileged EXEC. You can configure up to 16 hierarchical levels of commands for each mode. By configuring multiple passwords, you can allow different sets of users to have access to specified commands.

For example, if you want many users to have access to the **clear line** command, you can assign it level 2 security and distribute the level 2 password fairly widely. But if you want more restricted access to the **configure** command, you can assign it level 3 security and distribute that password to a more restricted group of users.

This section includes this configuration information:

- Setting the Privilege Level for a Command, page 9-7
- Changing the Default Privilege Level for Lines, page 9-8
- Logging into and Exiting a Privilege Level, page 9-9

Setting the Privilege Level for a Command

Beginning in privileged EXEC mode, follow these steps to set the privilege level for a command mode:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**privilege** *mode* **level** *level command*	Set the privilege level for a command. • For *mode*, enter **configure** for global configuration mode, **exec** for EXEC mode, **interface** for interface configuration mode, or **line** for line configuration mode. • For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the **enable** password. • For *command*, specify the command to which you want to restrict access.
Step 3	**enable password level** *level password*	Specify the enable password for the privilege level. • For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. • For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config** or **show privilege**	Verify your entries. The first command displays the password and access level configuration. The second command displays the privilege level configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

When you set a command to a privilege level, all commands whose syntax is a subset of that command are also set to that level. For example, if you set the **show ip traffic** command to level 15, the **show** commands and **show ip** commands are automatically set to privilege level 15 unless you set them individually to different levels.

To return to the default privilege for a given command, use the **no privilege** *mode* **level** *level command* global configuration command.

This example shows how to set the **configure** command to privilege level 14 and define *SecretPswd14* as the password users must enter to use level 14 commands:

```
Switch(config)# privilege exec level 14 configure
Switch(config)# enable password level 14 SecretPswd14
```

Changing the Default Privilege Level for Lines

Beginning in privileged EXEC mode, follow these steps to change the default privilege level for a line:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**line vty** *line*	Select the virtual terminal line on which to restrict access.
Step 3	**privilege level** *level*	Change the default privilege level for the line. For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the **enable** password.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config** or **show privilege**	Verify your entries. The first command displays the password and access level configuration. The second command displays the privilege level configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Users can override the privilege level you set using the **privilege level** line configuration command by logging in to the line and enabling a different privilege level. They can lower the privilege level by using the **disable** command. If users know the password to a higher privilege level, they can use that password to enable the higher privilege level. You might specify a high level or privilege level for your console line to restrict line usage.

To return to the default line privilege level, use the **no privilege level** line configuration command.

Logging into and Exiting a Privilege Level

Beginning in privileged EXEC mode, follow these steps to log in to a specified privilege level and to exit to a specified privilege level:

	Command	Purpose
Step 1	**enable** *level*	Log in to a specified privilege level. For *level*, the range is 0 to 15.
Step 2	**disable** *level*	Exit to a specified privilege level. For *level*, the range is 0 to 15.

Controlling Switch Access with TACACS+

This section describes how to enable and configure Terminal Access Controller Access Control System Plus (TACACS+), which provides detailed accounting information and flexible administrative control over authentication and authorization processes. TACACS+ is facilitated through authentication, authorization, accounting (AAA) and can be enabled only through AAA commands.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco IOS Security Command Reference for Release 12.1*.

This section contains this configuration information:

- Understanding TACACS+, page 9-9
- TACACS+ Operation, page 9-11
- Configuring TACACS+, page 9-11
- Displaying the TACACS+ Configuration, page 9-16

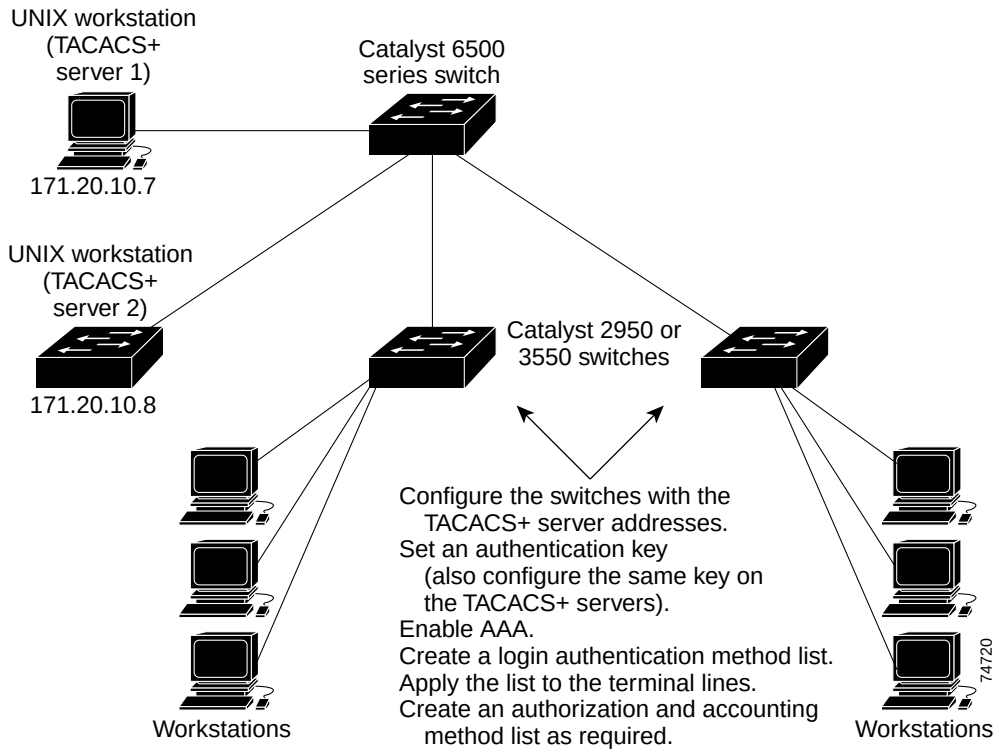
Understanding TACACS+

TACACS+ is a security application that provides centralized validation of users attempting to gain access to your switch. TACACS+ services are maintained in a database on a TACACS+ daemon typically running on a UNIX or Windows NT workstation. You should have access to and should configure a TACACS+ server before the configuring TACACS+ features on your switch.

TACACS+ provides for separate and modular authentication, authorization, and accounting facilities. TACACS+ allows for a single access control server (the TACACS+ daemon) to provide each service—authentication, authorization, and accounting—independently. Each service can be tied into its own database to take advantage of other services available on that server or on the network, depending on the capabilities of the daemon.

The goal of TACACS+ is to provide a method for managing multiple network access points from a single management service. Your switch can be a network access server along with other Cisco routers and access servers. A network access server provides connections to a single user, to a network or subnetwork, and to interconnected networks as shown in Figure 9-1.

Figure 9-1 Typical TACACS+ Network Configuration



TACACS+, administered through the AAA security services, can provide these services:

- Authentication—Provides complete control of authentication through login and password dialog, challenge and response, and messaging support.

  The authentication facility can conduct a dialog with the user (for example, after a username and password are provided, to challenge a user with several questions, such as home address, mother's maiden name, service type, and social security number). The TACACS+ authentication service can also send messages to user screens. For example, a message could notify users that their passwords must be changed because of the company's password aging policy.

- Authorization—Provides fine-grained control over user capabilities for the duration of the user's session, including but not limited to setting autocommands, access control, session duration, or protocol support. You can also enforce restrictions on what commands a user can execute with the TACACS+ authorization feature.

- Accounting—Collects and sends information used for billing, auditing, and reporting to the TACACS+ daemon. Network managers can use the accounting facility to track user activity for a security audit or to provide information for user billing. Accounting records include user identities, start and stop times, executed commands (such as PPP), number of packets, and number of bytes.

The TACACS+ protocol provides authentication between the switch and the TACACS+ daemon, and it ensures confidentiality because all protocol exchanges between the switch and the TACACS+ daemon are encrypted.

You need a system running the TACACS+ daemon software to use TACACS+ on your switch.

TACACS+ Operation

When a user attempts a simple ASCII login by authenticating to a switch using TACACS+, this process occurs:

1. When the connection is established, the switch contacts the TACACS+ daemon to obtain a username prompt, which is then displayed to the user. The user enters a username, and the switch then contacts the TACACS+ daemon to obtain a password prompt. The switch displays the password prompt to the user, the user enters a password, and the password is then sent to the TACACS+ daemon.

   TACACS+ allows a conversation to be held between the daemon and the user until the daemon receives enough information to authenticate the user. The daemon prompts for a username and password combination, but can include other items, such as the user's mother's maiden name.

2. The switch eventually receives one of these responses from the TACACS+ daemon:
   - ACCEPT—The user is authenticated and service can begin. If the switch is configured to require authorization, authorization begins at this time.
   - REJECT—The user is not authenticated. The user can be denied access or is prompted to retry the login sequence, depending on the TACACS+ daemon.
   - ERROR—An error occurred at some time during authentication with the daemon or in the network connection between the daemon and the switch. If an ERROR response is received, the switch typically tries to use an alternative method for authenticating the user.
   - CONTINUE—The user is prompted for additional authentication information.

   After authentication, the user undergoes an additional authorization phase if authorization has been enabled on the switch. Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.

3. If TACACS+ authorization is required, the TACACS+ daemon is again contacted, and it returns an ACCEPT or REJECT authorization response. If an ACCEPT response is returned, the response contains data in the form of attributes that direct the EXEC or NETWORK session for that user, determining the services that the user can access:
   - Telnet, Secure Shell (SSH), rlogin, or privileged EXEC services
   - Connection parameters, including the host or client IP address, access list, and user timeouts

Configuring TACACS+

This section describes how to configure your switch to support TACACS+. At a minimum, you must identify the host or hosts maintaining the TACACS+ daemon and define the method lists for TACACS+ authentication. You can optionally define method lists for TACACS+ authorization and accounting. A method list defines the sequence and methods to be used to authenticate, to authorize, or to keep accounts on a user. You can use method lists to designate one or more security protocols to be used, thus ensuring a backup system if the initial method fails. The software uses the first method listed to authenticate, to authorize, or to keep accounts on users; if that method does not respond, the software selects the next method in the list. This process continues until there is successful communication with a listed method or the method list is exhausted.

This section contains this configuration information:

- Default TACACS+ Configuration, page 9-12
- Identifying the TACACS+ Server Host and Setting the Authentication Key, page 9-12
- Configuring TACACS+ Login Authentication, page 9-13
- Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services, page 9-15
- Starting TACACS+ Accounting, page 9-16

Default TACACS+ Configuration

TACACS+ and AAA are disabled by default.

To prevent a lapse in security, you cannot configure TACACS+ through a network management application.When enabled, TACACS+ can authenticate users accessing the switch through the CLI.

Note Although TACACS+ configuration is performed through the CLI, the TACACS+ server authenticates HTTP connections that have been configured with a privilege level of 15.

Identifying the TACACS+ Server Host and Setting the Authentication Key

You can configure the switch to use a single server or AAA server groups to group existing server hosts for authentication. You can group servers to select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list and contains the list of IP addresses of the selected server hosts.

Beginning in privileged EXEC mode, follow these steps to identify the IP host or host maintaining TACACS+ server and optionally set the encryption key:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**tacacs-server host** *hostname* [**port** *integer*] [**timeout** *integer*] [**key** *string*]	Identify the IP host or hosts maintaining a TACACS+ server. Enter this command multiple times to create a list of preferred hosts. The software searches for hosts in the order in which you specify them. • For *hostname*, specify the name or IP address of the host. • (Optional) For **port** *integer*, specify a server port number. The default is port 49. The range is 1 to 65535. • (Optional) For **timeout** *integer*, specify a time in seconds the switch waits for a response from the daemon before it times out and declares an error. The default is 5 seconds. The range is 1 to 1000 seconds. • (Optional) For **key** *string*, specify the encryption key for encrypting and decrypting all traffic between the switch and the TACACS+ daemon. You must configure the same key on the TACACS+ daemon for encryption to be successful.
Step 3	**aaa new-model**	Enable AAA.

	Command	Purpose
Step 4	**aaa group server tacacs+** *group-name*	(Optional) Define the AAA server-group with a group name. This command puts the switch in a server group subconfiguration mode.
Step 5	**server** *ip-address*	(Optional) Associate a particular TACACS+ server with the defined server group. Repeat this step for each TACACS+ server in the AAA server group. Each server in the group must be previously defined in Step 2.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show tacacs**	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the specified TACACS+ server name or address, use the **no tacacs-server host** *hostname* global configuration command. To remove a server group from the configuration list, use the **no aaa group server tacacs+** *group-name* global configuration command. To remove the IP address of a TACACS+ server, use the **no server ip-address** server group subconfiguration command.

Configuring TACACS+ Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various interfaces. The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific interface before any of the defined authentication methods are performed. The only exception is the default method list (which, by coincidence, is named *default*). The default method list is automatically applied to all interfaces except those that have a named method list explicitly defined. A defined method list overrides the default method list.

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

Beginning in privileged EXEC mode, follow these steps to configure login authentication:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa new-model**	Enable AAA.
Step 3	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]	Create a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. • For *list-name*, specify a character string to name the list you are creating. • For *method1...*, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. Select one of these methods: • **enable**—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the **enable** *password* global configuration command. • **group tacacs+**—Uses TACACS+ authentication. Before you can use this authentication method, you must configure the TACACS+ server. For more information, see the "Identifying the TACACS+ Server Host and Setting the Authentication Key" section on page 9-12. • **line**—Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the **password** *password* line configuration command. • **local**—Use the local username database for authentication. You must enter username information in the database. Use the **username** *password* global configuration command. • **local-case**—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the **username** *name* **password** global configuration command. • **none**—Do not use any authentication for login.
Step 4	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]	Enter line configuration mode, and configure the lines to which you want to apply the authentication list.
Step 5	**login authentication** {**default** | *list-name*}	Apply the authentication list to a line or set of lines. • If you specify **default**, use the default list created with the **aaa authentication login** command. • For *list-name*, specify the list created with the **aaa authentication login** command.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable AAA, use the **no aaa new-model** global configuration command. To disable AAA authentication, use the **no aaa authentication login** {**default** | *list-name*} *method1* [*method2*...] global configuration command. To either disable TACACS+ authentication for logins or to return to the default value, use the **no login authentication** {**default** | *list-name*} line configuration command.

Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services

AAA authorization limits the services available to a user. When AAA authorization is enabled, the switch uses information retrieved from the user's profile, which is located either in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

You can use the **aaa authorization** global configuration command with the **tacacs+** keyword to set parameters that restrict a user's network access to privileged EXEC mode.

The **aaa authorization exec tacacs+ local** command sets these authorization parameters:

- Use TACACS+ for privileged EXEC access authorization if authentication was performed by using TACACS+.
- Use the local database if authentication was not performed by using TACACS+.

Note Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Beginning in privileged EXEC mode, follow these steps to specify TACACS+ authorization for privileged EXEC access and network services:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa authorization network tacacs+**	Configure the switch for user TACACS+ authorization for all network-related service requests.
Step 3	**aaa authorization exec tacacs+**	Configure the switch for user TACACS+ authorization to determine if the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable authorization, use the **no aaa authorization** {**network** | **exec**} *method1* global configuration command.

Starting TACACS+ Accounting

The AAA accounting feature tracks the services that users are accessing and the amount of network resources that they are consuming. When AAA accounting is enabled, the switch reports user activity to the TACACS+ security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, or auditing.

Beginning in privileged EXEC mode, follow these steps to enable TACACS+ accounting for each Cisco IOS privilege level and for network services:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa accounting network start-stop tacacs+**	Enable TACACS+ accounting for all network-related service requests.
Step 3	**aaa accounting exec start-stop tacacs+**	Enable TACACS+ accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable accounting, use the **no aaa accounting** {**network** | **exec**} {**start-stop**} *method1*... global configuration command.

Displaying the TACACS+ Configuration

To display TACACS+ server statistics, use the **show tacacs** privileged EXEC command.

Controlling Switch Access with RADIUS

This section describes how to enable and configure the Remote Authentication Dial-In User Service (RADIUS), which provides detailed accounting information and flexible administrative control over authentication and authorization processes. RADIUS is facilitated through AAA and can be enabled only through AAA commands.

Note For complete syntax and usage information for the commands used in this section, refer to the *Cisco IOS Security Command Reference for Release 12.1*.

This section contains this configuration information:

- Understanding RADIUS, page 9-17
- RADIUS Operation, page 9-18
- Configuring RADIUS, page 9-19
- Displaying the RADIUS Configuration, page 9-30

Understanding RADIUS

RADIUS is a distributed client/server system that secures networks against unauthorized access. RADIUS clients run on supported Cisco routers and switches, including Catalyst 3550 multilayer switches, Catalyst 2955 switches, and Catalyst 2950 switches. Clients send authentication requests to a central RADIUS server, which contains all user authentication and network service access information. The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (Cisco Secure Access Control Server version 3.0), Livingston, Merit, Microsoft, or another software provider. For more information, refer to the RADIUS server documentation.

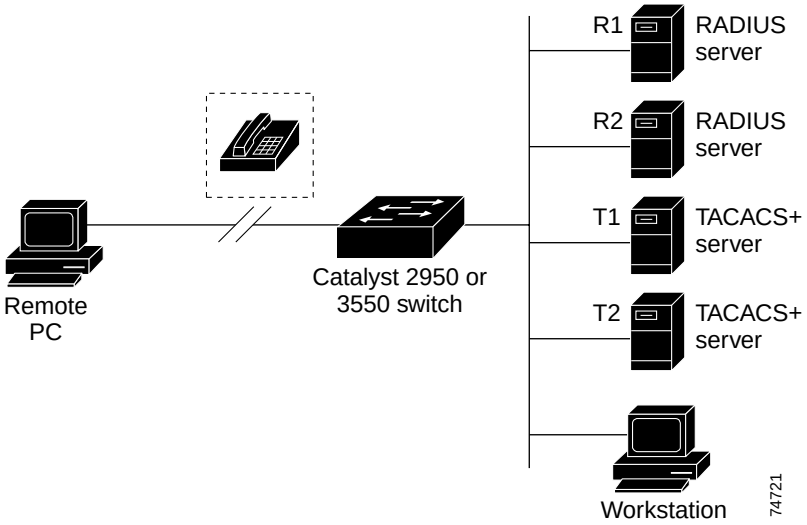
Use RADIUS in these network environments that require access security:

- Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors' access servers, dial-in users are authenticated through a RADIUS server that has been customized to work with the Kerberos security system.
- Turnkey network security environments in which applications support the RADIUS protocol, such as in an access environment that uses a *smart card* access control system. In one case, RADIUS has been used with Enigma's security cards to validates users and to grant access to network resources.
- Networks already using RADIUS. You can add a Cisco switch containing a RADIUS client to the network. This might be the first step when you make a transition to a TACACS+ server. See Figure 9-2 on page 9-18.
- Network in which the user must only access a single service. Using RADIUS, you can control user access to a single host, to a single utility such as Telnet, or to the network through a protocol such as IEEE 802.1X. For more information about this protocol, see Chapter 10, "Configuring 802.1X Port-Based Authentication."
- Networks that require resource accounting. You can use RADIUS accounting independently of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, showing the amount of resources (such as time, packets, bytes, and so forth) used during the session. An Internet service provider might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.

RADIUS is not suitable in these network security situations:

- Multiprotocol access environments. RADIUS does not support AppleTalk Remote Access (ARA), NetBIOS Frame Control Protocol (NBFCP), NetWare Asynchronous Services Interface (NASI), or X.25 PAD connections.
- Switch-to-switch or router-to-router situations. RADIUS does not provide two-way authentication. RADIUS can be used to authenticate from one device to a non-Cisco device if the non-Cisco device requires authentication.
- Networks using a variety of services. RADIUS generally binds a user to one service model.

Figure 9-2 Transitioning from RADIUS to TACACS+ Services



RADIUS Operation

When a user attempts to log in and authenticate to a switch that is access controlled by a RADIUS server, these events occur:

1. The user is prompted to enter a username and password.
2. The username and encrypted password are sent over the network to the RADIUS server.
3. The user receives one of these responses from the RADIUS server:
   a. ACCEPT—The user is authenticated.
   b. REJECT—The user is either not authenticated and is prompted to re-enter the username and password, or access is denied.
   c. CHALLENGE—A challenge requires additional data from the user.
   d. CHALLENGE PASSWORD—A response requests the user to select a new password.

The ACCEPT or REJECT response is bundled with additional data that is used for privileged EXEC or network authorization. Users must first successfully complete RADIUS authentication before proceeding to RADIUS authorization, if it is enabled. The additional data included with the ACCEPT or REJECT packets includes these items:

- Telnet, SSH, rlogin, or privileged EXEC services
- Connection parameters, including the host or client IP address, access list, and user timeouts

Configuring RADIUS

This section describes how to configure your switch to support RADIUS. At a minimum, you must identify the host or hosts that run the RADIUS server software and define the method lists for RADIUS authentication. You can optionally define method lists for RADIUS authorization and accounting.

A method list defines the sequence and methods to be used to authenticate, to authorize, or to keep accounts on a user. You can use method lists to designate one or more security protocols to be used (such as TACACS+ or local username lookup), thus ensuring a backup system if the initial method fails. The software uses the first method listed to authenticate, to authorize, or to keep accounts on users; if that method does not respond, the software selects the next method in the list. This process continues until there is successful communication with a listed method or the method list is exhausted.

You should have access to and should configure a RADIUS server before configuring RADIUS features on your switch.

This section contains this configuration information:

- Default RADIUS Configuration, page 9-19
- Identifying the RADIUS Server Host, page 9-19 (required)
- Configuring RADIUS Login Authentication, page 9-22 (required)
- Defining AAA Server Groups, page 9-24 (optional)
- Configuring RADIUS Authorization for User Privileged Access and Network Services, page 9-26 (optional)
- Starting RADIUS Accounting, page 9-27 (optional)
- Configuring Settings for All RADIUS Servers, page 9-28 (optional)
- Configuring the Switch to Use Vendor-Specific RADIUS Attributes, page 9-28 (optional)
- Configuring the Switch for Vendor-Proprietary RADIUS Server Communication, page 9-29 (optional)

Default RADIUS Configuration

RADIUS and AAA are disabled by default.

To prevent a lapse in security, you cannot configure RADIUS through a network management application. When enabled, RADIUS can authenticate users accessing the switch through the CLI.

Identifying the RADIUS Server Host

Switch-to-RADIUS-server communication involves several components:

- Host name or IP address
- Authentication destination port
- Accounting destination port
- Key string
- Timeout period
- Retransmission value

You identify RADIUS security servers by their host name or IP address, host name and specific UDP port numbers, or their IP address and specific UDP port numbers. The combination of the IP address and the UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address.

If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as a fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the switch tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order that they are configured.)

A RADIUS server and the switch use a shared secret text string to encrypt passwords and exchange responses. To configure RADIUS to use the AAA security commands, you must specify the host running the RADIUS server daemon and a secret text (key) string that it shares with the switch.

The timeout, retransmission, and encryption key values can be configured globally for all RADIUS servers, on a per-server basis, or in some combination of global and per-server settings. To apply these settings globally to all RADIUS servers communicating with the switch, use the three unique global configuration commands: **radius-server timeout**, **radius-server retransmit**, and **radius-server key**. To apply these values on a specific RADIUS server, use the **radius-server host** global configuration command.

Note If you configure both global and per-server functions (timeout, retransmission, and key commands) on the switch, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands. For information on configuring these setting on all RADIUS servers, see the "Configuring Settings for All RADIUS Servers" section on page 9-28.

You can configure the switch to use AAA server groups to group existing server hosts for authentication. For more information, see the "Defining AAA Server Groups" section on page 9-24.

Beginning in privileged EXEC mode, follow these steps to configure per-server RADIUS server communication. This procedure is required.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**radius-server host** {*hostname* | *ip-address*} [**auth-port** *port-number*] [**acct-port** *port-number*] [**timeout** *seconds*] [**retransmit** *retries*] [**key** *string*]	Specify the IP address or host name of the remote RADIUS server host. • (Optional) For **auth-port** *port-number*, specify the UDP destination port for authentication requests. • (Optional) For **acct-port** *port-number*, specify the UDP destination port for accounting requests. • (Optional) For **timeout** *seconds*, specify the time interval that the switch waits for the RADIUS server to reply before resending. The range is 1 to 1000. This setting overrides the **radius-server timeout** global configuration command setting. If no timeout is set with the **radius-server host** command, the setting of the **radius-server timeout** command is used. • (Optional) For **retransmit** *retries*, specify the number of times a RADIUS request is resent to a server if that server is not responding or responding slowly. The range is 1 to 1000. If no retransmit value is set with the **radius-server host** command, the setting of the **radius-server retransmit** global configuration command is used. • (Optional) For **key** *string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the **radius-server host** command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key. To configure the switch to recognize more than one host entry associated with a single IP address, enter this command as many times as necessary, making sure that each UDP port number is different. The switch software searches for hosts in the order in which you specify them. Set the timeout, retransmit, and encryption key values to use with the specific RADIUS host.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the specified RADIUS server, use the **no radius-server host** *hostname* | *ip-address* global configuration command.

This example shows how to configure one RADIUS server to be used for authentication and another to be used for accounting:

```
Switch(config)# radius-server host 172.29.36.49 auth-port 1612 key rad1
Switch(config)# radius-server host 172.20.36.50 acct-port 1618 key rad2
```

This example shows how to configure *host1* as the RADIUS server and to use the default ports for both authentication and accounting:

```
Switch(config)# radius-server host host1
```

Note You also need to configure some settings on the RADIUS server. These settings include the IP address of the switch and the key string to be shared by both the server and the switch. For more information, refer to the RADIUS server documentation.

Configuring RADIUS Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various interfaces. The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific interface before any of the defined authentication methods are performed. The only exception is the default method list (which, by coincidence, is named *default*). The default method list is automatically applied to all interfaces except those that have a named method list explicitly defined.

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

Beginning in privileged EXEC mode, follow these steps to configure login authentication. This procedure is required.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa new-model**	Enable AAA.

	Command	Purpose
Step 3	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]	Create a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. • For *list-name*, specify a character string to name the list you are creating. • For *method1...*, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. Select one of these methods: – **enable**—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the **enable** *password* global configuration command. – **group radius**—Use RADIUS authentication. Before you can use this authentication method, you must configure the RADIUS server. For more information, see the "Identifying the RADIUS Server Host" section on page 9-19. – **line**—Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the **password** *password* line configuration command. – **local**—Use the local username database for authentication. You must enter username information in the database. Use the **username** *name* **password** global configuration command. – **local-case**—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the **username** *password* global configuration command. – **none**—Do not use any authentication for login.
Step 4	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]	Enter line configuration mode, and configure the lines to which you want to apply the authentication list.
Step 5	**login authentication** {**default** | *list-name*}	Apply the authentication list to a line or set of lines. • If you specify **default**, use the default list created with the **aaa authentication login** command. • For *list-name*, specify the list created with the **aaa authentication login** command.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable AAA, use the **no aaa new-model** global configuration command. To disable AAA authentication, use the **no aaa authentication login** {**default** | *list-name*} *method1* [*method2...*] global configuration command. To either disable RADIUS authentication for logins or to return to the default value, use the **no login authentication** {**default** | *list-name*} line configuration command.

Defining AAA Server Groups

You can configure the switch to use AAA server groups to group existing server hosts for authentication. You select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list, which lists the IP addresses of the selected server hosts.

Server groups also can include multiple host entries for the same server if each entry has a unique identifier (the combination of the IP address and UDP port number), allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. If you configure two different host entries on the same RADIUS server for the same service, (for example, accounting), the second configured host entry acts as a fail-over backup to the first one.

You use the **server** group server configuration command to associate a particular server with a defined group server. You can either identify the server by its IP address or identify multiple host instances or entries by using the optional **auth-port** and **acct-port** keywords.

Beginning in privileged EXEC mode, follow these steps to define the AAA server group and associate a particular RADIUS server with it:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**radius-server host** {*hostname* | *ip-address*} [**auth-port** *port-number*] [**acct-port** *port-number*] [**timeout** *seconds*] [**retransmit** *retries*] [**key** *string*]	Specify the IP address or host name of the remote RADIUS server host. • (Optional) For **auth-port** *port-number*, specify the UDP destination port for authentication requests. • (Optional) For **acct-port** *port-number*, specify the UDP destination port for accounting requests. • (Optional) For **timeout** *seconds*, specify the time interval that the switch waits for the RADIUS server to reply before resending. The range is 1 to 1000. This setting overrides the **radius-server timeout** global configuration command setting. If no timeout is set with the **radius-server host** command, the setting of the **radius-server timeout** command is used. • (Optional) For **retransmit** *retries*, specify the number of times a RADIUS request is resent to a server if that server is not responding or responding slowly. The range is 1 to 1000. If no retransmit value is set with the **radius-server host** command, the setting of the **radius-server retransmit** global configuration command is used. • (Optional) For **key** *string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the **radius-server host** command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key. To configure the switch to recognize more than one host entry associated with a single IP address, enter this command as many times as necessary, making sure that each UDP port number is different. The switch software searches for hosts in the order in which you specify them. Set the timeout, retransmit, and encryption key values to use with the specific RADIUS host.
Step 3	**aaa new-model**	Enable AAA.
Step 4	**aaa group server radius** *group-name*	Define the AAA server-group with a group name. This command puts the switch in a server group configuration mode.
Step 5	**server** *ip-address*	Associate a particular RADIUS server with the defined server group. Repeat this step for each RADIUS server in the AAA server group. Each server in the group must be previously defined in Step 2.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries.

	Command	Purpose
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.
Step 9		Enable RADIUS login authentication. See the "Configuring RADIUS Login Authentication" section on page 9-22.

To remove the specified RADIUS server, use the **no radius-server host** *hostname* | *ip-address* global configuration command. To remove a server group from the configuration list, use the **no aaa group server radius** *group-name* global configuration command. To remove the IP address of a RADIUS server, use the **no server** *ip-address* server group configuration command.

In this example, the switch is configured to recognize two different RADIUS group servers (*group1* and *group2*). Group1 has two different host entries on the same RADIUS server configured for the same services. The second host entry acts as a fail-over backup to the first entry.

```
Switch(config)# radius-server host 172.20.0.1 auth-port 1000 acct-port 1001
Switch(config)# radius-server host 172.10.0.1 auth-port 1645 acct-port 1646
Switch(config)# aaa new-model
Switch(config)# aaa group server radius group1
Switch(config-sg-radius)# server 172.20.0.1 auth-port 1000 acct-port 1001
Switch(config-sg-radius)# exit
Switch(config)# aaa group server radius group2
Switch(config-sg-radius)# server 172.20.0.1 auth-port 2000 acct-port 2001
Switch(config-sg-radius)# exit
```

Configuring RADIUS Authorization for User Privileged Access and Network Services

AAA authorization limits the services available to a user. When AAA authorization is enabled, the switch uses information retrieved from the user's profile, which is in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

You can use the **aaa authorization** global configuration command with the **radius** keyword to set parameters that restrict a user's network access to privileged EXEC mode.

The **aaa authorization exec radius local** command sets these authorization parameters:

- Use RADIUS for privileged EXEC access authorization if authentication was performed by using RADIUS.
- Use the local database if authentication was not performed by using RADIUS.

Note Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Beginning in privileged EXEC mode, follow these steps to specify RADIUS authorization for privileged EXEC access and network services:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa authorization network radius**	Configure the switch for user RADIUS authorization for all network-related service requests.
Step 3	**aaa authorization exec radius**	Configure the switch for user RADIUS authorization to determine if the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable authorization, use the **no aaa authorization** {**network** | **exec**} *method1* global configuration command.

Starting RADIUS Accounting

The AAA accounting feature tracks the services that users are accessing and the amount of network resources that they are consuming. When AAA accounting is enabled, the switch reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, or auditing.

Beginning in privileged EXEC mode, follow these steps to enable RADIUS accounting for each Cisco IOS privilege level and for network services:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa accounting network start-stop radius**	Enable RADIUS accounting for all network-related service requests.
Step 3	**aaa accounting exec start-stop radius**	Enable RADIUS accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable accounting, use the **no aaa accounting** {**network** | **exec**} {**start-stop**} *method1...* global configuration command.

Configuring Settings for All RADIUS Servers

Beginning in privileged EXEC mode, follow these steps to configure global communication settings between the switch and all RADIUS servers:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**radius-server key** *string*	Specify the shared secret text string used between the switch and all RADIUS servers. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 3	**radius-server retransmit** *retries*	Specify the number of times the switch sends each RADIUS request to the server before giving up. The default is 3; the range 1 to 1000.
Step 4	**radius-server timeout** *seconds*	Specify the number of seconds a switch waits for a reply to a RADIUS request before resending the request. The default is 5 seconds; the range is 1 to 1000.
Step 5	**radius-server deadtime** *minutes*	Specify the number of minutes a RADIUS server, which is not responding to authentication requests, to be skipped, thus avoiding the wait for the request to timeout before trying the next configured server. The default is 0; the range is 1 to 1440 minutes.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your settings.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default setting for the retransmit, timeout, and deadtime, use the **no** forms of these commands.

Configuring the Switch to Use Vendor-Specific RADIUS Attributes

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific information between the switch and the RADIUS server by using the vendor-specific attribute (attribute 26). Vendor-specific attributes (VSAs) allow vendors to support their own extended attributes not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option by using the format recommended in the specification. Cisco's vendor-ID is 9, and the supported option has vendor-type 1, which is named *cisco-avpair*. The value is a string with this format:

```
protocol : attribute sep value *
```

Protocol is a value of the Cisco protocol attribute for a particular type of authorization. *Attribute* and *value* are an appropriate attribute-value (AV) pair defined in the Cisco TACACS+ specification, and *sep* is = for mandatory attributes and is * for optional attributes. The full set of features available for TACACS+ authorization can then be used for RADIUS.

For example, this AV pair activates Cisco's *multiple named ip address pools* feature during IP authorization (during PPP's IPCP address assignment):

```
cisco-avpair= "ip:addr-pool=first"
```

This example shows how to provide a user logging in from a switch with immediate access to privileged EXEC commands:

```
cisco-avpair= "shell:priv-lvl=15"
```

This example shows how to specify an authorized VLAN in the RADIUS server database:

```
cisco-avpair= "tunnel-type(#64)=VLAN(13)"
cisco-avpair= "tunnel-medium-type(#65)=802 media(6)"
cisco-avpair= "tunnel-private-group-ID(#81)=vlanid"
```

Other vendors have their own unique vendor-IDs, options, and associated VSAs. For more information about vendor-IDs and VSAs, refer to RFC 2138, "Remote Authentication Dial-In User Service (RADIUS)."

Beginning in privileged EXEC mode, follow these steps to configure the switch to recognize and use VSAs:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**radius-server vsa send** [**accounting** | **authentication**]	Enable the switch to recognize and use VSAs as defined by RADIUS IETF attribute 26. • (Optional) Use the **accounting** keyword to limit the set of recognized vendor-specific attributes to only accounting attributes. • (Optional) Use the **authentication** keyword to limit the set of recognized vendor-specific attributes to only authentication attributes. If you enter this command without keywords, both accounting and authentication vendor-specific attributes are used.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your settings.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

For a complete list of RADIUS attributes or more information about vendor-specific attribute 26, refer to the "RADIUS Attributes" appendix in the *Cisco IOS Security Configuration Guide for Release 12.1*.

Configuring the Switch for Vendor-Proprietary RADIUS Server Communication

Although an IETF draft standard for RADIUS specifies a method for communicating vendor-proprietary information between the switch and the RADIUS server, some vendors have extended the RADIUS attribute set in a unique way. Cisco IOS software supports a subset of vendor-proprietary RADIUS attributes.

As mentioned earlier, to configure RADIUS (whether vendor-proprietary or IETF draft-compliant), you must specify the host running the RADIUS server daemon and the secret text string it shares with the switch. You specify the RADIUS host and secret text string by using the **radius-server** global configuration commands.

Beginning in privileged EXEC mode, follow these steps to specify a vendor-proprietary RADIUS server host and a shared secret text string:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**radius-server host** {*hostname* | *ip-address*} **non-standard**	Specify the IP address or host name of the remote RADIUS server host and identify that it is using a vendor-proprietary implementation of RADIUS.
Step 3	**radius-server key** *string*	Specify the shared secret text string used between the switch and the vendor-proprietary RADIUS server. The switch and the RADIUS server use this text string to encrypt passwords and exchange responses. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your settings.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete the vendor-proprietary RADIUS host, use the **no radius-server host** {*hostname* | *ip-address*} **non-standard** global configuration command. To disable the key, use the **no radius-server key** global configuration command.

This example shows how to specify a vendor-proprietary RADIUS host and to use a secret key of *rad124* between the switch and the server:

```
Switch(config)# radius-server host 172.20.30.15 nonstandard
Switch(config)# radius-server key rad124
```

Displaying the RADIUS Configuration

To display the RADIUS configuration, use the **show running-config** privileged EXEC command.

Configuring the Switch for Local Authentication and Authorization

You can configure AAA to operate without a server by setting the switch to implement AAA in local mode. The switch then handles authentication and authorization. No accounting is available in this configuration.

Beginning in privileged EXEC mode, follow these steps to configure the switch for local AAA:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa new-model**	Enable AAA.
Step 3	**aaa authentication login default local**	Set the login authentication to use the local username database. The **default** keyword applies the local user database authentication to all interfaces.
Step 4	**aaa authorization exec local**	Configure user AAA authorization to determine if the user is allowed to run an EXEC shell by checking the local database.
Step 5	**aaa authorization network local**	Configure user AAA authorization for all network-related service requests.
Step 6	**username** *name* [**privilege** *level*] {**password** *encryption-type password*}	Enter the local database, and establish a username-based authentication system. Repeat this command for each user. • For *name*, specify the user ID as one word. Spaces and quotation marks are not allowed. • (Optional) For *level*, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 0 gives user EXEC mode access. • For *encryption-type*, enter 0 to specify that an unencrypted password follows. Enter 7 to specify that a hidden password follows. • For *password*, specify the password the user must enter to gain access to the switch. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the **username** command.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show running-config**	Verify your entries.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable AAA, use the **no aaa new-model** global configuration command. To disable authorization, use the **no aaa authorization** {**network** | **exec**} *method1* global configuration command.

Configuring the Switch for Secure Shell

This section describes how to configure the Secure Shell (SSH) feature. SSH is a cryptographic security feature that is subject to export restrictions. To use this feature, the cryptographic (encrypted) enhanced software image (EI) must be installed on your switch. You must obtain authorization to use this feature and to download the cryptographic software files. For more information, see the "Cryptographic Software Image Guidelines" section.This section contains this configuration information:

• Understanding SSH, page 9-32
• Cryptographic Software Image Guidelines, page 9-32
• Configuring SSH, page 9-32

Note For complete syntax and usage information for the commands used in this section, refer to the *"Secure Shell Commands"* section in the *Cisco IOS Security Command Reference for Release 12.2*.

Understanding SSH

SSH is a protocol that provides a secure, remote connection to a device. There are two versions of SSH: SSH version 1 and SSH version 2. This software release only supports SSH version 1.

SSH provides more security for remote connections than Telnet by providing strong encryption when a device is authenticated. The SSH feature has an SSH server and an SSH integrated client. SSH supports these user authentication methods:

- TACACS+ (for more information, see the "Controlling Switch Access with TACACS+" section on page 9-9)
- RADIUS (for more information, see the "Controlling Switch Access with RADIUS" section on page 9-17)
- Local authentication and authorization (for more information, see the "Configuring the Switch for Local Authentication and Authorization" section on page 9-30)

For more information about SSH, refer to the *"Configuring Secure Shell"* section in the *Cisco IOS Security Configuration Guide for Release 12.2*.

Note The SSH feature in this software release does not support IP Security (IPSec).

Cryptographic Software Image Guidelines

The SSH feature uses a large amount of switch memory, which limits the number of VLANs, trunk ports, and cluster members that you can configure on the switch. Before you download the cryptographic software image, your switch configuration must meet these conditions:

- The number of trunk ports multiplied by the number of VLANs on the switch must be less than or equal to 128. These are examples of switch configurations that meet this condition:
  - If the switch has 2 trunk ports, it can have up to 64 VLANs.
  - If the switch has 32 VLANs, it can have up to 4 trunk ports.
- If your switch is a cluster command switch, it can only support up to eight cluster members.

To obtain authorization to use this feature and to download the cryptographic software files, select **Catalyst 2950 Strong Cryptographic (3DES) Software** in the Software Download Web Site on Cisco.com. For more information about downloading this software, refer to the release notes for this release.

Configuring SSH

Before configuring SSH, download the cryptographic software image from Cisco.com. For more information, refer to the release notes for this release.

For information about configuring SSH and displaying SSH settings, refer to the "*Configuring Secure Shell*" section in the *Cisco IOS Security Configuration Guide for Release 12.2*.

CHAPTER 10

Configuring 802.1X Port-Based Authentication

This chapter describes how to configure IEEE 802.1X port-based authentication on your Catalyst 2950 or Catalyst 2955 switch to prevent unauthorized devices (clients) from gaining access to the network.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding 802.1X Port-Based Authentication, page 10-1
- Configuring 802.1X Authentication, page 10-7
- Displaying 802.1X Statistics and Status, page 10-16

Understanding 802.1X Port-Based Authentication

The IEEE 802.1X standard defines a client-server-based access control and authentication protocol that restricts unauthorized clients from connecting to a LAN through publicly accessible ports. The authentication server authenticates each client connected to a switch port before making available any services offered by the switch or the LAN.

Until the client is authenticated, 802.1X access control allows only Extensible Authentication Protocol over LAN (EAPOL) traffic through the port to which the client is connected. After authentication is successful, normal traffic can pass through the port.

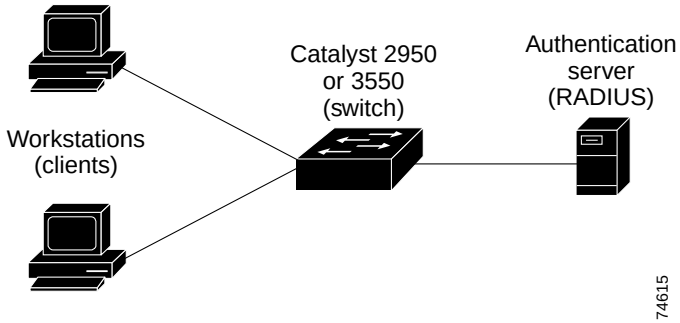
These sections describe 802.1X port-based authentication:

- Device Roles, page 10-2
- Authentication Initiation and Message Exchange, page 10-3
- Ports in Authorized and Unauthorized States, page 10-4
- Voice VLAN Ports, page 10-5
- Using 802.1X with Port Security, page 10-5
- Using 802.1X with VLAN Assignment, page 10-6
- Supported Topologies, page 10-7

Device Roles

With 802.1X port-based authentication, the devices in the network have specific roles as shown in Figure 10-1.

Figure 10-1 802.1X Device Roles



- *Client*—the device (workstation) that requests access to the LAN and switch services and responds to requests from the switch.The workstation must be running 802.1X-compliant client software such as that offered in the Microsoft Windows XP operating system. (The client is the *supplicant* in the IEEE 802.1X specification.)

  Note To resolve Windows XP network connectivity and 802.1X authentication issues, read the Microsoft Knowledge Base article at this URL: http://support.microsoft.com/support/kb/articles/Q303/5/97.ASP

- *Authentication server*—performs the actual authentication of the client. The authentication server validates the identity of the client and notifies the switch whether or not the client is authorized to access the LAN and switch services. Because the switch acts as the proxy, the authentication service is transparent to the client. In this release, the Remote Authentication Dial-In User Service (RADIUS) security system with Extensible Authentication Protocol (EAP) extensions is the only supported authentication server; it is available in Cisco Secure Access Control Server version 3.0. RADIUS operates in a client/server model in which secure authentication information is exchanged between the RADIUS server and one or more RADIUS clients.

- *Switch* (edge switch or wireless access point)—controls the physical access to the network based on the authentication status of the client. The switch acts as an intermediary (proxy) between the client and the authentication server, requesting identity information from the client, verifying that information with the authentication server, and relaying a response to the client. The switch includes the RADIUS client, which is responsible for encapsulating and decapsulating the EAP frames and interacting with the authentication server.

  When the switch receives EAPOL frames and relays them to the authentication server, the Ethernet header is stripped and the remaining EAP frame is re-encapsulated in the RADIUS format. The EAP frames are not modified or examined during encapsulation, and the authentication server must support EAP within the native frame format. When the switch receives frames from the authentication server, the server's frame header is removed, leaving the EAP frame, which is then encapsulated for Ethernet and sent to the client.

  The devices that can act as intermediaries include the Catalyst 3550 multilayer switch, the Catalyst 2950 switch, the Catalyst 2955 switch, or a wireless access point. These devices must be running software that supports the RADIUS client and 802.1X.

Authentication Initiation and Message Exchange

The switch or the client can initiate authentication. If you enable authentication on a port by using the **dot1x port-control auto** interface configuration command, the switch must initiate authentication when it determines that the port link state transitions from down to up. It then sends an EAP-request/identity frame to the client to request its identity (typically, the switch sends an initial identity/request frame followed by one or more requests for authentication information). Upon receipt of the frame, the client responds with an EAP-response/identity frame.

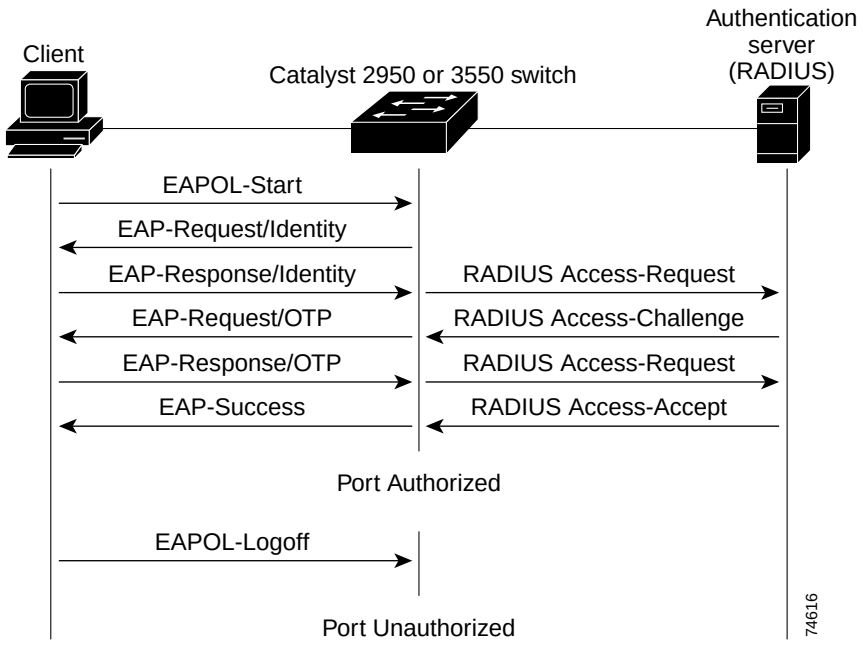
However, if during bootup, the client does not receive an EAP-request/identity frame from the switch, the client can initiate authentication by sending an EAPOL-start frame, which prompts the switch to request the client's identity.

Note If 802.1X is not enabled or supported on the network access device, any EAPOL frames from the client are dropped. If the client does not receive an EAP-request/identity frame after three attempts to start authentication, the client sends frames as if the port is in the authorized state. A port in the authorized state effectively means that the client has been successfully authenticated. For more information, see the "Ports in Authorized and Unauthorized States" section on page 10-4.

When the client supplies its identity, the switch begins its role as the intermediary, passing EAP frames between the client and the authentication server until authentication succeeds or fails. If the authentication succeeds, the switch port becomes authorized. For more information, see the "Ports in Authorized and Unauthorized States" section on page 10-4.

The specific exchange of EAP frames depends on the authentication method being used. Figure 10-2 shows a message exchange initiated by the client using the One-Time-Password (OTP) authentication method with a RADIUS server.

Figure 10-2 Message Exchange



Ports in Authorized and Unauthorized States

The switch port state determines whether or not the client is granted access to the network. The port starts in the *unauthorized* state. While in this state, the port disallows all ingress and egress traffic except for 802.1X protocol packets. When a client is successfully authenticated, the port transitions to the *authorized* state, allowing all traffic for the client to flow normally.

If a client that does not support 802.1X is connected to an unauthorized 802.1X port, the switch requests the client's identity. In this situation, the client does not respond to the request, the port remains in the unauthorized state, and the client is not granted access to the network.

In contrast, when an 802.1X-enabled client connects to a port that is not running the 802.1X protocol, the client initiates the authentication process by sending the EAPOL-start frame. When no response is received, the client sends the request for a fixed number of times. Because no response is received, the client begins sending frames as if the port is in the authorized state.

You control the port authorization state by using the **dot1x port-control** interface configuration command and these keywords:

- **force-authorized**—disables 802.1X authentication and causes the port to transition to the authorized state without any authentication exchange required. The port sends and receives normal traffic without 802.1X-based authentication of the client. This is the default setting.
- **force-unauthorized**—causes the port to remain in the unauthorized state, ignoring all attempts by the client to authenticate. The switch cannot provide authentication services to the client through the interface.
- **auto**—enables 802.1X authentication and causes the port to begin in the unauthorized state, allowing only EAPOL frames to be sent and received through the port. The authentication process begins when the link state of the port transitions from down to up or when an EAPOL-start frame is received. The switch requests the identity of the client and begins relaying authentication messages between the client and the authentication server. Each client attempting to access the network is uniquely identified by the switch by using the client's MAC address.

If the client is successfully authenticated (receives an Accept frame from the authentication server), the port state changes to authorized, and all frames from the authenticated client are allowed through the port. If the authentication fails, the port remains in the unauthorized state, but authentication can be retried. If the authentication server cannot be reached, the switch can resend the request. If no response is received from the server after the specified number of attempts, authentication fails, and network access is not granted.

When a client logs off, it sends an EAPOL-logoff message, causing the switch port to transition to the unauthorized state.

If the link state of a port transitions from up to down, or if an EAPOL-logoff frame is received, the port returns to the unauthorized state.

Voice VLAN Ports

Multiple VLAN access ports (MVAPs) are ports that belong to two VLANs. This configuration allows the separating of voice traffic and the data traffic onto different VLANs. A switch port configured with a voice VLAN has separate VLANs configured for carrying:

- The voice traffic to and from the IP phone.
- The data traffic to and from the workstation connected to the switch through the IP phone.

Thus, each port configured for voice VLAN is associated with a port VLAN identifier (PVID) which is the native VLAN of the port, and a voice VLAN identifier (VVID) that is used to configure the IP phone connected to the port.

When 802.1X is enabled on a port that has a voice VLAN, the VLAN remains down on the port (equivalent to an unauthenticated state) until a CDP message is received from an IP phone. The VLAN then becomes active, allowing the phone to work independently of 802.1X authentication. The VLAN becomes inactive on the port if the CDP entry times out or if it is cleared by using the **cdp clear table** privileged EXEC command.

A workstation connected to the port uses the PVID and is authenticated through 802.1X as usual. The IP phone has access to the VVID for its voice traffic irrespective of the authorized or unauthorized state of the port.

Only one client is allowed on the voice VLAN other workstations or IP phones are blocked. When you enable the multiple-hosts mode, when an 802.1X user is authenticated on the primary VLAN, additional clients on the voice VLAN are unrestricted after 802.1X authentication succeeds on the primary VLAN.

When 802.1X is enabled on a port, you cannot configure a port VLAN that is equal to a voice VLAN.

Using 802.1X with Port Security

For switches running the enhanced software image (EI), you can enable an 802.1X port for port security by using the **dot1x multiple-hosts** interface configuration command. You must also configure port security on the port by using the **switchport port-security** interface configuration command. With the multiple-hosts mode enabled, 802.1X authenticates the port, and port security manages network access for all MAC addresses, including that of the client. You can then limit the number or group of clients that can access the network through an 802.1X multiple-host port.

These are some examples of the interaction between 802.1X and port security on the switch:

- When a client is authenticated, and the port security table is not full, the client's MAC address is added to the port security list of secure hosts. The port then proceeds to come up normally.

  When a client is authenticated and manually configured for port security, it is guaranteed an entry in the secure host table (unless port security static aging has been enabled).

  A security violation occurs if the client is authenticated, but port security table is full. This can happen if the maximum number of secure hosts have been statically configured, or if the client ages out of the secure host table. If the client's address is aged out, its place in the secure host table can be taken by another host. In this case, you should enable periodic reauthentication with a shorter time period than the port security aging time.

  The port security violation modes determine the action for security violations. See the "Security Violations" section on page 19-5 for more information.

- When the client logs off, the port transitions back to an unauthenticated state and all dynamic entries in the secure host table are cleared, including the entry for the client. Normal authentication then takes place.
- If the port is administratively shut down the port becomes unauthenticated and all dynamic entries are removed from the secure host table.

See the"Enabling Multiple Hosts" section on page 10-15, and the "Configuring Port Security" section on page 19-4 for more information about enabling 802.1X and port security on your switch.

Using 802.1X with VLAN Assignment

For switches running the EI, you can use VLAN assignment to limit network access for certain users. With VLAN assignment, 802.1X-authenticated ports are assigned to a VLAN based on the username of the client connected to that port. The RADIUS server database maintains the username-to-VLAN mappings. After successful 802.1X authentication of the port, the RADIUS server sends the VLAN assignment to the user.

When configured on the switch and the RADIUS server, 802.1X with VLAN assignment has these characteristics:

- If no VLAN is supplied by the RADIUS server or AAA authorization is disabled, the port is configured in its access VLAN after successful authentication.
- If authorization is enabled but the VLAN information from the server is not valid, the port remains down in the unauthenticated state. This prevents ports from appearing unexpectedly in an inappropriate VLAN because of a configuration error.

  Configuration errors could include specifying a VLAN for a routed port, a malformed VLAN ID, a non-existent or internal (routed port) VLAN id, or attempting assignment to a voice VLAN ID.
- If authorization is enabled and all information from the server is valid, the port is placed in the specified VLAN after successful authentication.
- If the multiple-hosts mode is enabled, all hosts are in the same VLAN as the first authenticated user.
- If 802.1X is disabled on the port, it is returned to the configured access VLAN.

To configure VLAN assignment you need to:

- Enable AAA
- Enable 802.1X
- Assign vendor-specific tunnel attributes in the RADIUS server. The RADIUS server must return these attributes to the switch:
  - [64] Tunnel-Type = VLAN
  - [65] Tunnel-Medium-Type = 802
  - [81] Tunnel-Private-Group-ID = VLAN NAME

  Attribute [64] must contain the value *VLAN* (type 13). Attribute [65] must contain the value *802* (type 6). Attribute [81] specifies the *VLAN name* assigned to the 802.1X-authenticated user.

See the "Configuring the Switch to Use Vendor-Specific RADIUS Attributes" section on page 9-28 for examples of vendor-specific attributes.

Supported Topologies

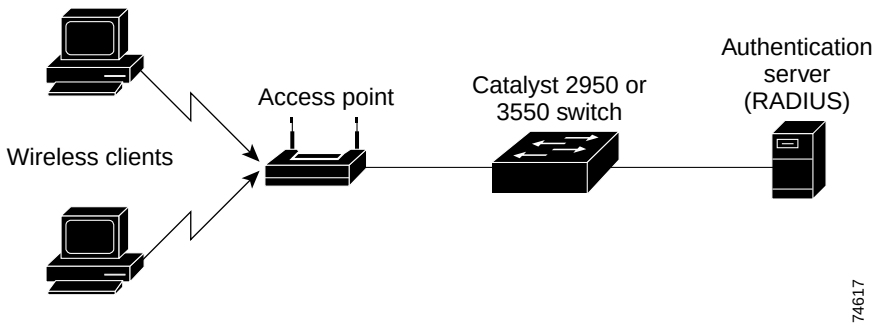
The 802.1X port-based authentication is supported in two topologies:

- Point-to-point
- Wireless LAN

In a point-to-point configuration (see Figure 10-1 on page 10-2), only one client can be connected to the 802.1X-enabled switch port. The switch detects the client when the port link state changes to the up state. If a client leaves or is replaced with another client, the switch changes the port link state to down, and the port returns to the unauthorized state.

Figure 10-3 shows 802.1X port-based authentication in a wireless LAN. The 802.1X port is configured as a multiple-host port that becomes authorized as soon as one client is authenticated. When the port is authorized, all other hosts indirectly attached to the port are granted access to the network. If the port becomes unauthorized (re-authentication fails or an EAPOL-logoff message is received), the switch denies access to the network to all of the attached clients. In this topology, the wireless access point is responsible for authenticating the clients attached to it, and the wireless access point acts as a client to the switch.

Figure 10-3 Wireless LAN Example



Configuring 802.1X Authentication

These sections describe how to configure 802.1X port-based authentication on your switch:

- Default 802.1X Configuration, page 10-8
- 802.1X Configuration Guidelines, page 10-9
- Enabling 802.1X Authentication, page 10-9 (required)
- Configuring the Switch-to-RADIUS-Server Communication, page 10-11 (required)
- Enabling Periodic Re-Authentication, page 10-12 (optional)
- Manually Re-Authenticating a Client Connected to a Port, page 10-13 (optional)
- Changing the Quiet Period, page 10-13 (optional)
- Changing the Switch-to-Client Retransmission Time, page 10-14 (optional)
- Setting the Switch-to-Client Frame-Retransmission Number, page 10-14 (optional)
- Enabling Multiple Hosts, page 10-15 (optional)
- Resetting the 802.1X Configuration to the Default Values, page 10-16 (optional)

Default 802.1X Configuration

Table 10-1 shows the default 802.1X configuration.

Table 10-1 Default 802.1X Configuration

Feature	Default Setting
Authentication, authorization, and accounting (AAA)	Disabled.
RADIUS server • IP address • UDP authentication port • Key	 • None specified. • 1812. • None specified.
Per-interface 802.1X enable state	Disabled (force-authorized). The port sends and receives normal traffic without 802.1X-based authentication of the client.
Periodic re-authentication	Disabled.
Number of seconds between re-authentication attempts	3600 seconds.
Quiet period	60 seconds (number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client).
Retransmission time	30 seconds (number of seconds that the switch should wait for a response to an EAP request/identity frame from the client before resending the request).
Maximum retransmission number	2 times (number of times that the switch will send an EAP-request/identity frame before restarting the authentication process).
Multiple host support	Disabled.
Client timeout period	30 seconds (when relaying a request from the authentication server to the client, the amount of time the switch waits for a response before resending the request to the client.
Authentication server timeout period	30 seconds (when relaying a response from the client to the authentication server, the amount of time the switch waits for a reply before resending the response to the server. This setting is not configurable.)

802.1X Configuration Guidelines

These are some configuration guidelines and operating characteristics of 802.1X authentication:

- When 802.1X is enabled, ports are authenticated before any other Layer 2 features are enabled.
- The 802.1X protocol is supported on Layer 2 static-access ports, but it is not supported on these port types:
  - Trunk port—If you try to enable 802.1X on a trunk port, an error message appears, and 802.1X is not enabled. If you try to change the mode of an 802.1X-enabled port to trunk, the port mode is not changed.
  - Dynamic ports—A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable 802.1X on a dynamic port, an error message appears, and 802.1X is not enabled. If you try to change the mode of an 802.1X-enabled port to dynamic, the port mode is not changed.
  - Dynamic-access ports—If you try to enable 802.1X on a dynamic-access (VLAN Query Protocol [VQP]) port, an error message appears, and 802.1X is not enabled. If you try to change an 802.1X-enabled port to dynamic VLAN assignment, an error message appears, and the VLAN configuration is not changed.
  - EtherChannel port—Before enabling 802.1X on the port, you must first remove it from the EtherChannel. If you try to enable 802.1X on an EtherChannel or on an active port in an EtherChannel, an error message appears, and 802.1X is not enabled. If you enable 802.1X on a not-yet active port of an EtherChannel, the port does not join the EtherChannel.
  - Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) destination ports—You can enable 802.1X on a port that is a SPAN or RSPAN destination or reflector port. However, 802.1X is disabled until the port is removed as a SPAN or RSPAN destination or reflector port. You can enable 802.1X on a SPAN or RSPAN source port.
- For switches running the EI, if you try to enable 802.1X on a secure port without enabling the multiple-hosts mode, the switch returns an error message, and 802.1X is not enabled. If you try to change an 802.1X-enabled port to a secure port without enabling the multiple-hosts mode, the switch returns an error message, and the security settings are not changed.
- When 802.1X is enabled on a port, you cannot configure a port VLAN that is equal to a voice VLAN.

Enabling 802.1X Authentication

To enable 802.1X port-based authentication, you must enable AAA and specify the authentication method list. A method list describes the sequence and authentication methods to be queried to authenticate a user.

The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle, the authentication process stops, and no other authentication methods are attempted.

To allow VLAN assignment (for switches running the EI), you need to enable AAA authorization to configure the switch for all network-related service requests.

Beginning in privileged EXEC mode, follow these steps to configure 802.1X port-based authentication. This procedure is required.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**aaa new-model**	Enable AAA.
Step 3	**aaa authentication dot1x** {**default**} *method1* [*method2*...]	Create an 802.1X authentication method list. To create a default list that is used when a named list is *not* specified in the **authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. Enter at least one of these keywords: • **group radius**—Use the list of all RADIUS servers for authentication. • **none**—Use no authentication. The client is automatically authenticated by the switch without using the information supplied by the client.
Step 4	**aaa authorization network** {**default**} **group radius**	(Optional) Configure the switch for user RADIUS authorization for all network-related service requests, such as VLAN assignment. **Note**
Step 5	**interface** *interface-id*	Enter interface configuration mode, and specify the interface connected to the client that is to be enabled for 802.1X authentication.
Step 6	**dot1x port-control auto**	Enable 802.1X authentication on the interface. For feature interaction information with trunk, dynamic, dynamic-access, EtherChannel, secure, and SPAN ports, see the "802.1X Configuration Guidelines" section on page 10-9.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show dot1x**	Verify your entries. Check the Status column in the 802.1X Port Summary section of the display. An *enabled* status means the port-control value is set either to **auto** or to **force-unauthorized**.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable AAA, use the **no aaa new-model** global configuration command. To disable 802.1X AAA authentication, use the **no aaa authentication dot1x** {**default** | *list-name*} *method1* [*method2*...] global configuration command. To disable 802.1X AAA authorization, use the **no aaa authorization** global configuration command. To disable 802.1X authentication, use the **dot1x port-control force-authorized** or the **no dot1x port-control** interface configuration command.

This example shows how to enable AAA and 802.1X on Fast Ethernet port 0/1:

```
Switch# configure terminal
Switch(config)# aaa new-model
Switch(config)# aaa authentication dot1x default group radius
Switch(config)# interface fastethernet0/1
Switch(config-if)# switchport mode access
Switch(config-if)# dot1x port-control auto
Switch(config-if)# end
```

Configuring the Switch-to-RADIUS-Server Communication

RADIUS security servers are identified by their host name or IP address, host name and specific UDP port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port number creates a unique identifier, which enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, authentication—the second host entry configured acts as the fail-over backup to the first one. The RADIUS host entries are tried in the order that they were configured.

Beginning in privileged EXEC mode, follow these steps to configure the RADIUS server parameters on the switch. This procedure is required.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string*	Configure the RADIUS server parameters on the switch. For *hostname* | *ip-address*, specify the host name or IP address of the remote RADIUS server. For **auth-port** *port-number*, specify the UDP destination port for authentication requests. The default is 1812. For **key** *string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server. **Note** Always configure the key as the last item in the **radius-server host** command syntax because leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon. If you want to use multiple RADIUS servers, re-enter this command.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete the specified RADIUS server, use the **no radius-server host** {*hostname* | *ip-address*} global configuration command.

This example shows how to specify the server with IP address 172.20.39.46 as the RADIUS server, to use port 1612 as the authorization port, and to set the encryption key to *rad123*, matching the key on the RADIUS server:

```
Switch(config)# radius-server host 172.l20.39.46 auth-port 1612 key rad123
```

You can globally configure the timeout, retransmission, and encryption key values for all RADIUS servers by using the **radius-server host** global configuration command. If you want to configure these options on a per-server basis, use the **radius-server timeout**, **radius-server retransmit**, and the **radius-server key** global configuration commands. For more information, see the "Configuring Settings for All RADIUS Servers" section on page 9-28.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the switch and the key string to be shared by both the server and the switch. For more information, refer to the RADIUS server documentation.

Enabling Periodic Re-Authentication

You can enable periodic 802.1X client re-authentication and specify how often it occurs. If you do not specify a time period before enabling re-authentication, the number of seconds between re-authentication attempts is 3600.

Automatic 802.1X client re-authentication is a global setting and cannot be set for clients connected to individual ports. To manually re-authenticate the client connected to a specific port, see the "Manually Re-Authenticating a Client Connected to a Port" section on page 10-13.

Beginning in privileged EXEC mode, follow these steps to enable periodic re-authentication of the client and to configure the number of seconds between re-authentication attempts:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**dot1x re-authentication**	Enable periodic re-authentication of the client, which is disabled by default.
Step 3	**dot1x timeout re-authperiod** *seconds*	Set the number of seconds between re-authentication attempts. The range is 1 to 4294967295; the default is 3600 seconds. This command affects the behavior of the switch only if periodic re-authentication is enabled.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show dot1x**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable periodic re-authentication, use the **no dot1x re-authentication** global configuration command.To return to the default number of seconds between re-authentication attempts, use the **no dot1x timeout re-authperiod** global configuration command.

This example shows how to enable periodic re-authentication and set the number of seconds between re-authentication attempts to 4000:

```
Switch(config)# dot1x re-authentication
Switch(config)# dot1x timeout re-authperiod 4000
```

Manually Re-Authenticating a Client Connected to a Port

You can manually re-authenticate the client connected to a specific port at any time by entering the **dot1x re-authenticate interface** *interface-id* privileged EXEC command. If you want to enable or disable periodic re-authentication, see the "Enabling Periodic Re-Authentication" section on page 10-12.

This example shows how to manually re-authenticate the client connected to Fast Ethernet port 0/1:

```
Switch# dot1x re-authenticate interface fastethernet0/1
Starting reauthentication on FastEthernet0/1
```

Changing the Quiet Period

When the switch cannot authenticate the client, the switch remains idle for a set period of time, and then tries again. The idle time is determined by the quiet-period value. A failed authentication of the client might occur because the client provided an invalid password. You can provide a faster response time to the user by entering a smaller number than the default.

Beginning in privileged EXEC mode, follow these steps to change the quiet period:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**dot1x timeout quiet-period** *seconds*	Set the number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client. The range is 0 to 65535 seconds; the default is 60.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show dot1x**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default quiet time, use the **no dot1x timeout quiet-period** global configuration command.

This example shows how to set the quiet time on the switch to 30 seconds:

```
Switch(config)# dot1x timeout quiet-period 30
```

Changing the Switch-to-Client Retransmission Time

The client responds to the EAP-request/identity frame from the switch with an EAP-response/identity frame. If the switch does not receive this response, it waits a set period of time (known as the retransmission time) and then resends the frame.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to change the amount of time that the switch waits for client notification:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**dot1x timeout tx-period** *seconds*	Set the number of seconds that the switch waits for a response to an EAP-request/identity frame from the client before resending the request. The range is 1 to 65535 seconds; the default is 30.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show dot1x**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default retransmission time, use the **no dot1x timeout tx-period** global configuration command.

This example shows how to set 60 as the number of seconds that the switch waits for a response to an EAP-request/identity frame from the client before resending the request:

```
Switch(config)# dot1x timeout tx-period 60
```

Setting the Switch-to-Client Frame-Retransmission Number

In addition to changing the switch-to-client retransmission time, you can change the number of times that the switch sends an EAP-request/identity frame (assuming no response is received) to the client before restarting the authentication process.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to set the switch-to-client frame-retransmission number:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**dot1x max-req** *count*	Set the number of times that the switch sends an EAP-request/identity frame to the client before restarting the authentication process. The range is 1 to 10; the default is 2.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show dot1x**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default retransmission number, use the **no dot1x max-req** global configuration command.

This example shows how to set 5 as the number of times that the switch sends an EAP-request/identity request before restarting the authentication process:

```
Switch(config)# dot1x max-req 5
```

Enabling Multiple Hosts

You can attach multiple hosts to a single 802.1X-enabled port as shown in Figure 10-3 on page 10-7. In this mode, only one of the attached hosts must be authorized for all hosts to be granted network access. If the port becomes unauthorized (re-authentication fails or an EAPOL-logoff message is received), all attached clients are denied access to the network.

With the multiple-hosts mode enabled, you can use 802.1X to authenticate the port and port security to manage network access for all MAC addresses, including that of the client (for switches running the EI).

Beginning in privileged EXEC mode, follow these steps to allow multiple hosts (clients) and port security on an 802.1X-authorized port that has the **dot1x port-control** interface configuration command set to **auto**.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to which multiple hosts are indirectly attached.
Step 3	**dot1x multiple-hosts**	Allow multiple hosts (clients) and port security on an 802.1X-authorized port. Make sure that the **dot1x port-control** interface configuration command set is set to **auto** for the specified interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show dot1x interface** *interface-id*	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable multiple hosts on the port, use the **no dot1x multiple-hosts** interface configuration command.

This example shows how to enable 802.1X on Fast Ethernet interface 0/1 and to allow multiple hosts:

```
Switch(config)# interface fastethernet0/1
Switch(config-if)# dot1x port-control auto
Switch(config-if)# dot1x multiple-hosts
```

Resetting the 802.1X Configuration to the Default Values

Beginning in privileged EXEC mode, follow these steps to reset the 802.1X configuration to the default values:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**dot1x default**	Reset the configurable 802.1X parameters to the default values.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show dot1x**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Displaying 802.1X Statistics and Status

To display 802.1X statistics for all interfaces, use the **show dot1x statistics** privileged EXEC command. To display 802.1X statistics for a specific interface, use the **show dot1x statistics interface** *interface-id* privileged EXEC command.

To display the 802.1X administrative and operational status for the switch, use the **show dot1x** privileged EXEC command. To display the 802.1X administrative and operational status for a specific interface, use the **show dot1x interface** *interface-id* privileged EXEC command.

For detailed information about the fields in these displays, refer to the command reference for this release.

Configuring the Switch Interfaces

This chapter describes the types of interfaces on a Catalyst 2950 or Catalyst 2955 switch and how to configure them. The chapter has these sections:

- Understanding Interface Types, page 11-1
- Using the Interface Command, page 11-4
- Configuring Switch Interfaces, page 11-9
- Monitoring and Maintaining the Interfaces, page 11-15

Note For complete syntax and usage information for the commands used in this chapter, refer to the switch command reference for this release and the online *Cisco IOS Interface Command Reference for Release 12.1.*

Understanding Interface Types

This section describes the different types of interfaces supported by the switch with references to chapters that contain more detailed information about configuring these interface types. The rest of the chapter describes configuration procedures for switch ports.

Switch ports are Layer 2-only interfaces associated with a physical port. They are used for managing the physical interface and associated Layer 2 protocols and do not handle routing or bridging. A switch port can be an access port or a trunk port.

You can configure a port as an access port or trunk port or let the Dynamic Trunking Protocol (DTP) operate on a per-port basis to determine if a switch port should be an access port or a trunk port by negotiating with the port on the other end of the link.

Configure switch ports by using the **switchport** interface configuration commands. For detailed information about configuring access port and trunk port characteristics, see Chapter 15, “Configuring VLANs.”

These sections describes these types of interfaces :

- Access Ports, page 11-2
- Trunk Ports, page 11-2
- Port-Based VLANs, page 11-3
- EtherChannel Port Groups, page 11-3
- Connecting Interfaces, page 11-4

Access Ports

An access port belongs to and carries the traffic of only one VLAN (unless it is configured as a voice VLAN port). Traffic is received and sent in native formats with no VLAN tagging. Traffic arriving on an access port is assumed to belong to the VLAN assigned to the port. If an access port receives an 802.1P- or 802.1Q-tagged packet for the VLAN assigned to the port, the packet is forwarded. If the port receives an 802.1P- or 802.1Q-tagged packet for another VLAN, the packet is dropped, the source address is not learned, and the frame is counted in the *No destination* statistic.

The Catalyst 2950 switch does not support ISL-tagged packets. If the switch receives an ISL-tagged packet, the packet is flooded in the native VLAN of the port on which it was received because the MAC destination address in the ISL-tagged packet is a multicast address.

Two types of access ports are supported:

- Static access ports are manually assigned to a VLAN.
- VLAN membership of dynamic access ports is learned through incoming packets. By default, a dynamic access port is a member of no VLAN, and forwarding to and from the port is enabled only when the VLAN membership of the port is discovered. Dynamic access ports on the switch are assigned to a VLAN by a VLAN Membership Policy Server (VMPS). The VMPS can be a Catalyst 6000 series switch; the Catalyst 2950 or Catalyst 2955 switch does not support the function of a VMPS.

You can also configure an access port with an attached Cisco IP Phone to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone. From more information about voice VLAN ports, see Chapter 15, “Configuring VLANs.”

Trunk Ports

A trunk port carries the traffic of multiple VLANs and by default is a member of all VLANs in the VLAN database. Only IEEE 802.1Q trunk ports are supported. An IEEE 802.1Q trunk port supports simultaneous tagged and untagged traffic. An 802.1Q trunk port is assigned a default Port VLAN ID (PVID), and all untagged traffic travels on the port default PVID. All untagged traffic and tagged traffic with a NULL VLAN ID are assumed to belong to the port default PVID. A packet with a VLAN ID equal to the outgoing port default PVID is sent untagged. All other traffic is sent with a VLAN tag.

Although by default, a trunk port is a member of every VLAN known to the VTP, you can limit VLAN membership by configuring an allowed list of VLANs for each trunk port. The list of allowed VLANs does not affect any other port but the associated trunk port. By default, all possible VLANs (VLAN ID 1 to 1005 when the standard software image [SI] is installed or VLAN ID 1 to 4094 when the enhanced software image [EI] is installed) are in the allowed list. A trunk port can only become a member of a VLAN if VTP knows of the VLAN and the VLAN is in the enabled state. If VTP learns of a new, enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of that VLAN and traffic is forwarded to and from the trunk port for that VLAN. If VTP learns of a new, enabled VLAN that is not in the allowed list for a trunk port, the port does not become a member of the VLAN, and no traffic for the VLAN is forwarded to or from the port.

Note VLAN 1 cannot be excluded from the allowed list.

For more information about trunk ports, see Chapter 15, “Configuring VLANs.”

Port-Based VLANs

A VLAN is a switched network that is logically segmented by function, team, or application, without regard to the physical location of the users. For more information about VLANs, see Chapter 15, "Configuring VLANs." Packets received on a port are forwarded only to ports that belong to the same VLAN as the receiving port. Network devices in different VLANs cannot communicate with one another without a Layer 3 device to route traffic between the VLANs.

VLAN partitions provide hard firewalls for traffic in the VLAN, and each VLAN has its own MAC address table. A VLAN comes into existence when a local port is configured to be associated with the VLAN, when the VLAN Trunking Protocol (VTP) learns of its existence from a neighbor on a trunk, or when a user creates a VLAN.

To configure normal-range VLANs (VLAN IDs 1 to 1005), use the **vlan** *vlan-id* global configuration command to enter config-vlan mode or the **vlan database** privileged EXEC command to enter VLAN configuration mode. The VLAN configurations for VLAN IDs 1 to 1005 are saved in the VLAN database. To configure extended-range VLANs (VLAN IDs 1006 to 4094) when the EI is installed, you must use config-vlan mode with VTP mode set to transparent. Extended-range VLANs are not added to the VLAN database. When VTP mode is transparent, the VTP and VLAN configuration is saved in the switch running configuration, and you can save it in the switch startup configuration file by entering the **copy running-config startup-config** privileged EXEC command.

Add ports to a VLAN by using the **switchport** interface configuration commands:

- Identify the interface.
- For a trunk port, set trunk characteristics, and if desired, define the VLANs to which it can belong.
- For an access port, set and define the VLAN to which it belongs.

EtherChannel Port Groups

EtherChannel port groups provide the ability to treat multiple switch ports as one switch port. These port groups act as a single logical port for high-bandwidth connections between switches or between switches and servers. An EtherChannel balances the traffic load across the links in the channel. If a link within the EtherChannel fails, traffic previously carried over the failed link changes to the remaining links. You can group multiple trunk ports into one logical trunk port or group multiple access ports into one logical access port. Most protocols operate over either single ports or aggregated switch ports and do not recognize the physical ports within the port group. Exceptions are the DTP, the Cisco Discovery Protocol (CDP), the Port Aggregation Protocol (PAgP), and Link Aggregation Control Protocol (LACP) which operate only on physical ports.

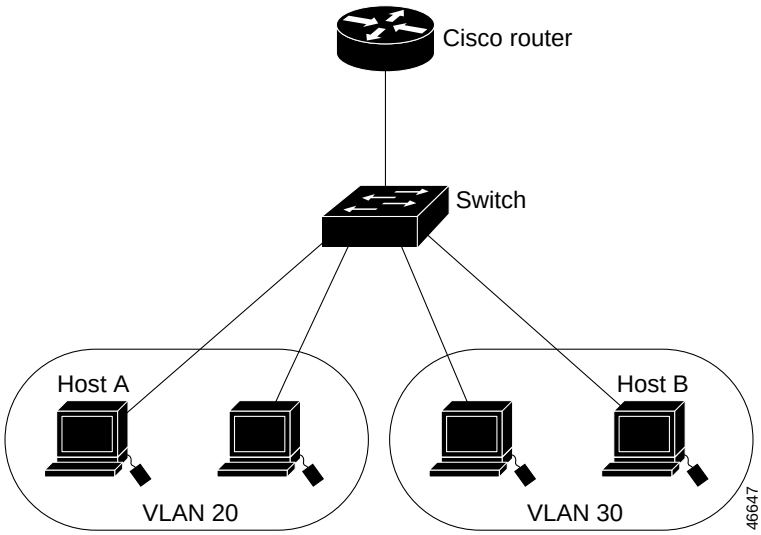
When you configure an EtherChannel, you create a port-channel logical interface and assign an interface to the EtherChannel. For Layer 2 interfaces, the logical interface is dynamically created. You manually assign an interface to the EtherChannel by using the **channel-group** interface configuration command. This command binds the physical and logical ports together. For more information, see Chapter 28, "Configuring EtherChannels."

Connecting Interfaces

Devices within a single VLAN can communicate directly through any switch. Ports in different VLANs cannot exchange data without going through a routing device or routed interface.

With a standard Layer 2 switch, ports in different VLANs have to exchange information through a router. In the configuration shown in Figure 11-1, when Host A in VLAN 20 sends data to Host B in VLAN 30, it must go from Host A to the switch, to the router, back to the switch, and then to Host B.

Figure 11-1 Connecting VLANs with Layer 2 Switches



Using the Interface Command

To configure a physical interface (port), use the **interface** global configuration command to enter interface configuration mode and to specify the interface type, slot, and number.

- Type—Fast Ethernet (fastethernet or fa) for 10/100 Ethernet or Gigabit Ethernet (gigabitethernet or gi)
- Slot—The slot number on the switch (always 0 on this switch).
- Port number—The interface number on the switch. The port numbers always begin at 1, starting at the left when facing the front of the switch, for example, fastethernet 0/1, fastethernet 0/2. If there is more than one media type (for example, 10/100 ports and Gigabit Ethernet ports), the port number starts again with the second media: gigabitethernet 0/1, gigabitethernet 0/2.

You can identify physical interfaces by physically checking the interface location on the switch. You can also use the IOS **show** privileged EXEC commands to display information about a specific interface or all the interfaces on the switch. The remainder of this chapter primarily provides physical interface configuration procedures.

This section describes how to configure all types of interfaces and how to configure a range of interfaces:

- Procedures for Configuring Interfaces, page 11-5
- Configuring a Range of Interfaces, page 11-6
- Configuring and Using Interface-Range Macros, page 11-8

Procedures for Configuring Interfaces

These general instructions apply to all interface configuration processes.

Step 1 Enter the **configure terminal** command at the privileged EXEC prompt:

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#
```

Step 2 Enter the **interface** global configuration command. Identify the interface type and the number of the connector. In this example, Gigabit Ethernet interface 0/1 is selected:

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)#
```

Note You do not need to add a space between the interface type and interface number. For example, in the preceding line, you can specify either **gigabitethernet 0/1**, **gigabitethernet0/1**, **gi 0/1**, or **gi0/1**.

Step 3 Follow each **interface** command with the interface configuration commands your particular interface requires. The commands you enter define the protocols and applications that will run on the interface. The commands are collected and applied to the interface when you enter another interface command or enter **end** to return to privileged EXEC mode.

You can also configure a range of interfaces by using the **interface range** or **interface range macro** global configuration commands. Interfaces configured in a range must be the same type and must be configured with the same feature options.

Step 4 After you configure an interface, verify its status by using the **show** privileged EXEC commands listed in the "Monitoring and Maintaining the Interfaces" section on page 11-15.

Enter the **show interfaces** privileged EXEC command to see a list of all interfaces on or configured for the switch. A report is provided for each interface that the device supports or for the specified interface:

```
Switch# show interfaces
Vlan1 is up, line protocol is up
  Hardware is EtherSVI, address is 0000.0000.0000 (bia 0000.0000.00
  Internet address is 10.1.1.64/24
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:35, output 2d14h, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 1 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     264251 packets input, 163850228 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     380 packets output, 26796 bytes, 0 underruns
     0 output errors, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

```
FastEthernet0/1 is up, line protocol is down
  Hardware is Fast Ethernet, address is 0000.0000.0001 (bia 0000.00
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Auto-duplex, Auto-speed
  input flow-control is off, output flow-control is off
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 2 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out

<output truncated>
```

Configuring a Range of Interfaces

You can use the **interface range** global configuration command to configure multiple interfaces with the same configuration parameters. When you enter the interface-range configuration mode, all command parameters that you enter are attributed to all interfaces within that range until you exit this mode.

Beginning in privileged EXEC mode, follow these steps to configure a range of interfaces with the same parameters:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface range** {*port-range* | **macro** *macro_name*}	Enter interface-range configuration mode by entering the range of interfaces (VLANs or physical ports) to be configured. • You can use the **interface range** command to configure up to five port ranges or a previously defined macro. • The **macro** variable is explained in the "Configuring and Using Interface-Range Macros" section on page 11-8. • Each comma-separated *port-range* must consist of the same port type. You do not need to enter spaces before or after the comma. • When you define a range, the space between the first port and the hyphen is required.
Step 3		You can now use the normal configuration commands to apply the configuration parameters to all interfaces in the range.
Step 4	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 5	**show interfaces** [*interface-id*]	Verify the configuration of the interfaces in the range.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

When using the **interface range** global configuration command, note these guidelines:

- Valid entries for *port-range*:
  - **vlan** *vlan-ID - vlan-ID*, where VLAN ID is from 1 to 1005 with the SI installed or 1 to 4094 with the EI installed
  - **fastethernet** slot/{*first port*} - {*last port*}, where slot is **0**
  - **gigabitethernet** slot/{*first port*} - {*last port*}, where slot is **0**
  - **port-channel** *port-channel-number - port-channel-number*, where *port-channel-number* is from 1 to 6
- You must add a space between the interface numbers and the hyphen when using the **interface range** command. For example, the command **interface range fastethernet 0/1 - 5** is a valid range; the command **interface range fastethernet 0/1-5** is not a valid range.
- The **interface range** command works only with VLAN interfaces that have been configured with the **interface vlan** command (the **show running-config** privileged EXEC command output shows the configured VLAN interfaces). VLAN interfaces that do not appear by using the **show running-config** command cannot be used with the **interface range** command.
- All interfaces in a range must be the same type; that is, all Fast Ethernet ports, all Gigabit Ethernet ports, all EtherChannel ports, or VLAN interfaces.

This example shows how to use the **interface range** global configuration command to enable Fast Ethernet interfaces 0/1 to 0/5:

```
Switch# configure terminal
Switch(config)# interface range fastethernet0/1 - 5
Switch(config-if-range)# no shutdown
Switch(config-if-range)#
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet0/2, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet0/3, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet0/4, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet0/5, changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/05,
changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/3, changed
state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/4, changed
state to up
```

This example shows how to use a comma to add different interface type strings to the range to enable all Fast Ethernet interfaces in the range 0/1 to 0/3 and Gigabit Ethernet interfaces 0/1 and 0/2:

```
Switch# configure terminal
Switch(config)# interface range fastethernet0/1 - 3, gigabitethernet0/1 - 2
Switch(config-if-range)# no shutdown
Switch(config-if-range)#
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet0/2, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface FastEthernet0/3, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
*Oct  6 08:29:28: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to up
```

```
*Oct  6 08:29:29: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/ 1,
changed state to up
*Oct  6 08:29:29: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/ 2,
changed state to up
*Oct  6 08:29:29: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/ 3,
changed state to up
```

If you enter multiple configuration commands while you are in interface-range mode, each command is executed as it is entered. The commands are not batched together and executed after you exit interface-range mode. If you exit interface-range configuration mode while the commands are being executed, some commands might not be executed on all interfaces in the range. Wait until the command prompt reappears before exiting interface-range configuration mode.

Configuring and Using Interface-Range Macros

You can create an interface-range macro to automatically select a range of interfaces for configuration. Before you can use the **macro** keyword in the **interface range macro** global configuration command string, you must use the **define interface-range** global configuration command to define the macro.

Beginning in privileged EXEC mode, follow these steps to define an interface-range macro:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**define interface-range** *macro_name interface-range*	Define the interface-range macro, and save it in NVRAM. • The *macro_name* is a 32-character maximum character string. • A macro can contain up to five comma-separated interface ranges. You do not need to enter spaces before or after the comma. • Each *interface-range* must consist of the same port type.
Step 3	**interface range macro** *macro_name*	Select the interface range to be configured by using the values saved in the interface-range macro called *macro_name.* You can now use the normal configuration commands to apply the configuration to all interfaces in the defined macro.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config | include define**	Show the defined interface-range macro configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no define interface-range** *macro_name* global configuration command to delete a macro.

When using the **define interface-range** global configuration command, note these guidelines:

- Valid entries for *interface-range*:
  - **vlan** *vlan-ID - vlan-ID*, where VLAN ID is from 1 to 1005 with the SI installed or 1 to 4094 with the EI installed
  - **fastethernet** slot/{*first port*} - {*last port*}, where slot is **0**
  - **gigabitethernet** slot/{*first port*} - {*last port*}, where slot is **0**
  - **port-channel** *port-channel-number - port-channel-number*, where *port-channel-number* is from 1 to 6.

- You must add a space between the interface numbers and the hyphen when entering an *interface-range*. For example, **fastethernet 0/1 - 5** is a valid range; **fastethernet 0/1-5** is not a valid range.
- The VLAN interfaces must have been configured with the **interface vlan** command. The **show running-config** privileged EXEC command output shows the configured VLAN interfaces. VLAN interfaces that do not appear by using the **show running-config** command cannot be used as *interface-ranges*.
- All interfaces in a range must be the same type; that is, all Fast Ethernet ports, all Gigabit Ethernet ports, all EtherChannel ports, or all VLANs, but you can combine multiple interface types in a macro.

This example shows how to define an interface-range macro named *enet_list* to select Fast Ethernet ports 1 to 4 and to verify the macro configuration:

```
Switch# configure terminal
Switch(config)# define interface-range enet_list fastethernet0/1 - 4
Switch(config)# end
Switch# show running-config | include define
define interface-range enet_list FastEthernet0/1 - 4
```

This example shows how to create a multiple-interface macro named *macro1*:

```
Switch# configure terminal
Switch(config)# define interface-range macro1 gigabitethernet0/1 - 2, fastethernet0/5 - 7
Switch(config)# end
Switch#
```

This example shows how to enter interface range configuration mode for the interface-range macro *enet_list*:

```
Switch# configure terminal
Switch(config)# interface range macro enet_list
Switch(config-if-range)#
```

This example shows how to delete the interface-range macro *enet_list* and to verify that it has been deleted.

```
Switch# configure terminal
Switch(config)# no define interface-range enet_list
Switch# show run | include define
```

Configuring Switch Interfaces

The switch supports these interface types:

- Physical ports—Switch ports, including access and trunk ports
- VLANs—Switch virtual interfaces (SVIs)
- Port-channels—EtherChannel of interfaces

These sections describe the default interface configuration and the optional features that you can configure on most physical interfaces:

- Default Ethernet Interface Configuration, page 11-10
- Configuring Interface Speed and Duplex Mode, page 11-11
- Configuring IEEE 802.3X Flow Control on Gigabit Ethernet Ports, page 11-13
- Adding a Description for an Interface, page 11-15

Default Ethernet Interface Configuration

Table 11-1 shows the Ethernet interface default configuration. For more details on the VLAN parameters listed in the table, see Chapter 15, "Configuring VLANs." For details on controlling traffic to the port, see Chapter 19, "Configuring Port-Based Traffic Control."

Table 11-1 Default Ethernet Interface Configuration

Feature	Default Setting
Operating mode	Layer 2.
Allowed VLAN range	VLANs 1 to 1005 with the SI installed or 1 to 4094 with the EI installed.
Default VLAN (for access ports)	VLAN 1.
Native VLAN (for 802.1Q trunks)	VLAN 1.
VLAN trunking	Switchport mode dynamic desirable (supports DTP).
Port enable state	All ports are enabled.
Port description	None defined.
Speed	Autonegotiate.
Duplex mode	Autonegotiate.
Flow control	Flow control is set to *off* for **receive** and *desired* for **send** for Gigabit Ethernet ports.
EtherChannel (PAgP) and Link Aggregation Control Protocol (LACP)	Disabled on all Ethernet ports. See Chapter 28, "Configuring EtherChannels."
Broadcast, multicast, and unicast storm control	Disabled. See the "Default Storm Control Configuration" section on page 19-2.
Protected port	Disabled. See the "Configuring Protected Ports" section on page 19-3.
Port security	Disabled. See the "Default Port Security Configuration" section on page 19-6.
Port Fast	Disabled.

Configuring Interface Speed and Duplex Mode

The 10/100 Ethernet interfaces on the switch operate in 10 or 100 Mbps and in either full- or half- duplex mode. The 10/100/1000 Ethernet interfaces on the Catalyst 2950T-24 switch operate at 10, 100, or 1000 Mbps only in full-duplex mode. The 10/100/1000 Ethernet interfaces on the Catalyst 2955T-24 switch operate at 10 or 100 Mbps in either half- or full-duplex mode or at 1000 Mbps only in full-duplex mode.

In full-duplex mode, two stations can send and receive at the same time. When packets can flow in both directions simultaneously, effective Ethernet bandwidth doubles to 20 Mbps for 10-Mbps interfaces, to 200 Mbps for Fast Ethernet interfaces, and to 2 Gbps for Gigabit interfaces. Full-duplex communication is often an effective solution to collisions, which are major constrictions in Ethernet networks. Normally, 10-Mbps ports operate in half-duplex mode, which means that stations can either receive or send.

You can configure interface speed on Fast Ethernet (10/100-Mbps) and Gigabit Ethernet (10/100/1000-Mbps) interfaces. You cannot configure speed on 100BASE-FX, 1000BASE-SX, and Gigabit Interface Converter (GBIC) interfaces.

You can configure duplex mode on any Fast Ethernet interfaces that are not set to autonegotiate. You can configure duplex mode on the 10/100/1000 ports on the Catalyst 2955T-24 switch but cannot configure duplex mode on these interfaces:

- 100BASE-FX ports on the Catalyst 2950C-24 switch
- 1000BASE-SX ports on the Catalyst 2950SX-24 switch
- GBIC ports
- 10/100/1000 ports on the Catalyst 2950T-24 switch

Note You cannot configure speed or duplex mode on Gigabit Interface Converter (GBIC) ports, but for certain types of GBICs, you can configure speed to not negotiate (**nonegotiate**) if connected to a device that does not support autonegotiation.

These sections describe how to configure the interface speed and duplex mode:

- Configuration Guidelines, page 11-11
- Setting the Interface Speed and Duplex Parameters, page 11-12

Configuration Guidelines

When configuring an interface speed and duplex mode, note these guidelines:

- Ethernet ports set to 1000 Mbps should always be set to full duplex.
- Gigabit Ethernet ports that do not match the settings of an attached device can lose connectivity and do not generate statistics.
- If both ends of the line support autonegotiation, we highly recommend the default setting of **auto**negotiation.
- When connecting an interface to a 100BASE-T device that does not autonegotiate, set the speed to a non-auto value (for example, nonegotiate) and set the duplex mode to full or half to match the device. The speed value and duplex mode must be explicitly set.

- When connecting an interface to a Gigabit Ethernet device that does not autonegotiate, disable autonegotiation on the switch and set the duplex and flow control parameters to be compatible with the remote device.
- 100BASE-FX ports operate only at 100 Mbps and in full-duplex mode.
- 1000BASE-SX ports operate only at 1000 Mbps and in full-duplex mode.
- 1000BASE-T GBICs operate only at 1000Mbps and in full-duplex mode.
- 10/100/1000 ports on the Catalyst 2950T-24 switch operate only in full-duplex mode.
- 10/100/1000 ports on the Catalyst 2955T-12 switch can operate at 10 or 100 Mbps in either half- or full-duplex mode. The ports can operate at 1000 Mbps only in full-duplex mode.
- GigaStack-to-GigaStack cascade connections operate in half-duplex mode, and GigaStack-to-GigaStack point-to-point connections operate in full-duplex mode.
- When Spanning Tree Protocol (STP) is enabled and a port is reconfigured, the switch can take up to 30 seconds to check for loops. The port LED is amber while STP reconfigures.

Caution Changing the interface speed and duplex mode configuration might shut down and re-enable the interface during the reconfiguration.

Setting the Interface Speed and Duplex Parameters

Beginning in privileged EXEC mode, follow these steps to set the speed and duplex mode for a physical interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode and the physical interface identification.
Step 3	**speed** {**10** | **100** | **1000** | **auto**| **nonegotiate**}	Enter the appropriate speed parameter for the interface, or enter **auto** or **nonegotiate**. **Note** The **1000** keyword is available only for 10/100/1000 Mbps ports. 100BASE-FX ports operate only at 100 Mbps. 1000BASE-SX ports and GBIC module ports operate only at 1000 Mbps. The **nonegotiate** keyword is available only for 1000BASE-SX, -LX, and -ZX GBIC ports.
Step 4	**duplex** {**auto** | **full** | **half**}	Enter the duplex parameter for the interface. **Note** The 100BASE-FX, 1000BASE-SX, and the 10/100/1000 ports operate only in full-duplex mode. **Note** The **duplex** keyword is not available on GBIC ports. **Note** The **duplex** keyword is not available on the 10/100/1000 ports on the Catalyst 2950T-24 switch.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show interfaces** *interface-id*	Display the interface speed and duplex mode configuration.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no speed** and **no duplex** interface configuration commands to return the interface to the default speed and duplex settings (autonegotiate). To return all interface settings to the defaults, use the **default interface** *interface-id* interface configuration command.

This example shows how to set the interface speed to 10 Mbps and the duplex mode to half on Fast Ethernet interface 0/3 and to verify the configuration:

```
Switch# configure terminal
Switch(config)# interface fastethernet0/3
Switch(config-if)# speed 10
Switch(config-if)# duplex half
Switch(config)# end
Switch# show running-config
Building configuration...

Current configuration : 1954 bytes
!
version 12.1
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Switch
!
<output truncated>
!
interface FastEthernet0/3
 switchport mode trunk
 no ip address
 duplex half
 speed 10
!
<output truncated>
```

Configuring IEEE 802.3X Flow Control on Gigabit Ethernet Ports

Flow control is supported only on the 10/100/1000, 1000BASE-SX, and GBIC ports. Flow control enables connected Gigabit Ethernet ports to control traffic rates during congestion by allowing congested nodes to pause link operation at the other end. If one port experiences congestion and cannot receive any more traffic, it notifies the other port to stop sending until the condition clears. When the local device detects any congestion at its end, it can notify the link partner or the remote device of the congestion by sending a pause frame. Upon receipt of a pause frame, the remote device stops sending any data packets, which prevents any loss of data packets during the congestion period.

Note We strongly recommend that you do not configure IEEE 802.3X flowcontrol when quality of service (QoS) is configured on the switch. Before configuring flowcontrol on an interface, make sure to return to the default QoS settings listed in the "Default Standard QoS Configuration" section on page 27-16.

Flow control can be implemented in two forms, symmetric and asymmetric. The symmetric implementation is suitable for point-to-point links, and asymmetric is suitable for hub-to-end node connections, where it is desirable for the hub to pause the end system, but not vice-versa. You use the **flowcontrol** interface configuration command to set the interface's ability to **receive** and **send** pause frames to **on**, **off**, or **desired**. The default state for Gigabit Ethernet ports is **receive off** and **send desired**. The default state for Fast Ethernet ports is **receive off** and **send off**.

These rules apply to flow control settings on the device:

- **receive on** (or **desired**) and **send on**: Flow control operates in both directions; both the local and the remote devices can send pause frames to show link congestion.
- **receive on** (or **desired**) and **send desired**: The port can receive pause frames and can send pause frames if the attached device supports flow control.
- **receive on** (or **desired**) and **send off**: The port cannot send pause frames but can operate with an attached device that is required to or can send pause frames; the port can receive pause frames.
- **receive off** and **send on**: The port sends pause frames if the remote device supports flow control but cannot receive pause frames from the remote device.
- **receive off** and **send desired**: The port cannot receive pause frames but can send pause frames if the attached device supports flow control.
- **receive off** and **send off**: Flow control does not operate in either direction. In case of congestion, no indication is given to the link partner, and no pause frames are sent or received by either device.

Note For details about the command settings and the resulting flow control resolution on local and remote ports, refer to the **flowcontrol** interface configuration command in the command reference for this release.

Beginning in privileged EXEC mode, follow these steps to configure flow control on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**interface** *interface-id*	Enter interface configuration mode and the physical interface to be configured.
Step 3	**flowcontrol** {**receive** | **send**} {**on** | **off** | **desired**}	Configure the flow control mode for the port.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id*	Verify the interface flow control settings.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable flow control, use the **flowcontrol receive off** and **flowcontrol send off** interface configuration commands.

This example shows how to turn off all flow control on Gigabit Ethernet interface 0/1 and to display the results:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# flowcontrol receive off
Switch(config-if)# flowcontrol send off
Switch(config-if)# end
Switch# show running-config
```

Adding a Description for an Interface

You can add a description about an interface to help you remember its function. The description appears in the output of these commands: **show configuration**, **show running-config**, and **show interfaces**.

Beginning in privileged EXEC mode, follow these steps to add a description for an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**interface** *interface-id*	Enter interface configuration mode, and enter the interface for which you are adding a description.
Step 3	**description** *string*	Add a description (up to 240 characters) for an interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **description** or **show running-config**	Verify your entry.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no description** interface configuration command to delete the description.

This example shows how to add a description on Fast Ethernet interface 0/4 and to verify the description:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# interface fastethernet0/4
Switch(config-if)# description Connects to Marketing
Switch(config-if)# end
Switch# show interfaces fastethernet0/4 description
Interface Status         Protocol Description
Fa0/4     up             down     Connects to Marketing
```

Monitoring and Maintaining the Interfaces

You can perform the tasks in these sections to monitor and maintain interfaces:

- Monitoring Interface and Controller Status, page 11-15
- Clearing and Resetting Interfaces and Counters, page 11-17
- Shutting Down and Restarting the Interface, page 11-18

Monitoring Interface and Controller Status

Commands entered at the privileged EXEC prompt display information about the interface, including the version of the software and the hardware, the controller status, and statistics about the interfaces. Table 11-2 lists some of these interface monitoring commands. (You can display the full list of **show** commands by using the **show ?** command at the privileged EXEC prompt.) These commands are fully described in the *Cisco IOS Interface Command Reference for Release 12.1*.

Table 11-2 show Commands for Interfaces

Command	Purpose
show interfaces [*interface-id*]	Display the status and configuration of all interfaces or a specific interface.
show interfaces [*interface-id*] **capabilities** [**module** {*module-number*}]	Display the capabililities of an interface. If you do not specify a module, the capabilities for all ports on the switch are displayed.
show interfaces *interface-id* **status** [**err-disabled**]	Display interface status or a list of interfaces in error-disabled state.
show interfaces [*interface-id*] **switchport**	Display administrative and operational status of switching (nonrouting) ports.
show interfaces [*interface-id*] **description**	Display the description configured on an interface or all interfaces and the interface status.
show ip interface [*interface-id*]	Display the usability status of all interfaces configured for IP or the specified interface.
show running-config interface [*interface-id*]	Display the running configuration in RAM for the interface.
show version	Display the hardware configuration, software version, the names and sources of configuration files, and the boot images.

This example shows how to display the status of all interfaces:

```
Switch# show interfaces status

Port    Name               Status       Vlan       Duplex  Speed Type
Fa0/1                      connected    1          a-full  a-100 10/100BaseTX
Fa0/2                      notconnect   1            auto   auto 10/100BaseTX
Fa0/3                      notconnect   1            auto   auto 10/100BaseTX

<output truncated>

Fa0/23                     notconnect   1            auto   auto 10/100BaseTX
Fa0/24                     notconnect   1            auto   auto 10/100BaseTX
Gi0/1                      notconnect   1            auto   auto unknown
Gi0/2                      notconnect   1            auto   auto unknown
```

This example shows how to display the status of switching ports:

```
Switch# show interfaces switchport
Name: Fa0/1
Switchport:Enabled
Administrative Mode:dynamic desirable
Operational Mode:static access
Administrative Trunking Encapsulation:negotiate
Negotiation of Trunking:On
Access Mode VLAN:1 (default)
Trunking Native Mode VLAN:1 (default)
Voice VLAN:none
Administrative private-vlan host-association:none
Administrative private-vlan mapping:none
Operational private-vlan:none
Trunking VLANs Enabled:ALL
Pruning VLANs Enabled:2-1001
Capture Mode: Disabled
Capture VLANs Allowed:ALL

Protected:true
Unknown unicast blocked:disabled
```

```
Unknown multicast blocked:disabled

Voice VLAN:none (Inactive)
Appliance trust:none

Name: Fa0/2
Switchport: Enabled
Administrative Mode: static access
Operational Mode: down

<output truncated>
```

This example shows how to display the running configuration of Fast Ethernet interface 0/2:

```
Switch# show running-config interface fastethernet0/2
Building configuration...

Current configuration : 131 bytes
!
interface FastEthernet0/2
 switchport mode access
 switchport protected
 no ip address
 mls qos cos 7
 mls qos cos override
end
```

For additional examples of the **show interfaces** privileged EXEC command, refer to the command reference for this release.

Clearing and Resetting Interfaces and Counters

Table 11-3 lists the privileged EXEC mode **clear** commands that you can use to clear counters and reset interfaces.

Table 11-3 Clear Commands for Interfaces

Command	Purpose
clear counters [*interface-id*]	Clear interface counters.
clear interface *interface-id*	Reset the hardware logic on an interface.
clear line [*number* | **console 0** | **vty** *number*]	Reset the hardware logic on an asynchronous serial line.

To clear the interface counters shown by the **show interfaces** privileged EXEC command, use the **clear counters** privileged EXEC command. The **clear counters** command clears all current interface counters from the interface unless optional arguments are specified to clear only a specific interface type from a specific interface number.

Note The **clear counters** privileged EXEC command does not clear counters retrieved by using Simple Network Management Protocol (SNMP), but only those seen with the **show interfaces** privileged EXEC command output.

This example shows how to clear and reset the counters on Fast Ethernet interface 0/5:

```
Switch# clear counters fastethernet0/5
Clear "show interface" counters on this interface [confirm] y
Switch#
*Sep 30 08:42:55: %CLEAR-5-COUNTERS: Clear counter on interface FastEthernet0/5
by vty1 (171.69.115.10)
```

Use the **clear interface** or **clear line** privileged EXEC command to clear and reset an interface or serial line. Under most circumstances, you do not need to clear the hardware logic on interfaces or serial lines.

This example shows how to clear and reset Fast Ethernet interface 0/5:

```
Switch# clear interface fastethernet0/5
```

Shutting Down and Restarting the Interface

Shutting down an interface disables all functions on the specified interface and marks the interface as unavailable on all monitoring command displays. This information is communicated to other network servers through all dynamic routing protocols. The interface is not mentioned in any routing updates.

Beginning in privileged EXEC mode, follow these steps to shut down an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** {**vlan** *vlan-id*} | {{**fastethernet** | **gigabitethernet**} *interface-id*} | {**port-channel** *port-channel-number*}	Select the interface to be configured.
Step 3	**shutdown**	Shut down an interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entry.

Use the **no shutdown** interface configuration command to restart the interface.

This example shows how to shut down Fast Ethernet interface 0/5:

```
Switch# configure terminal
Switch(config)# interface fastethernet0/5
Switch(config-if)# shutdown
Switch(config-if)#
*Sep 30 08:33:47: %LINK-5-CHANGED: Interface FastEthernet0/5, changed state to a
administratively down
```

This example shows how to re-enable Fast Ethernet interface 0/5:

```
Switch# configure terminal
Switch(config)# interface fastethernet0/5
Switch(config-if)# no shutdown
Switch(config-if)#
*Sep 30 08:36:00: %LINK-3-UPDOWN: Interface FastEthernet0/5, changed state to up
```

To verify that an interface is disabled, enter the **show interfaces** privileged EXEC command. A disabled interface is shown as *administratively down* in the **show interfaces** command output.

Configuring STP

This chapter describes how to configure the Spanning Tree Protocol (STP) on your Catalyst 2950 or Catalyst 2955 switch.

For information about the Rapid Spanning Tree Protocol (RSTP), the Multiple Spanning Tree Protocol (MSTP), and the per-VLAN rapid spanning tree (PVRST), see Chapter 13, "Configuring RSTP and MSTP." For information about optional spanning-tree features, see Chapter 14, "Configuring Optional Spanning-Tree Features."

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding Spanning-Tree Features, page 12-1
- Configuring Spanning-Tree Features, page 12-10
- Displaying the Spanning-Tree Status, page 12-21

Understanding Spanning-Tree Features

These sections describe how spanning-tree features work:

- STP Overview, page 12-2
- Supported Spanning-Tree Instances, page 12-2
- Bridge Protocol Data Units, page 12-2
- Election of the Root Switch, page 12-3
- Bridge ID, Switch Priority, and Extended System ID, page 12-4
- Spanning-Tree Timers, page 12-5
- Creating the Spanning-Tree Topology, page 12-5
- Spanning-Tree Interface States, page 12-6
- Spanning-Tree Address Management, page 12-8
- STP and IEEE 802.1Q Trunks, page 12-8

- Spanning Tree and Redundant Connectivity, page 12-9
- Accelerated Aging to Retain Connectivity, page 12-9

STP Overview

STP is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

When you create fault-tolerant internetworks, you must have a loop-free path between all nodes in a network. The spanning-tree algorithm calculates the best loop-free path throughout a switched Layer 2 network. Switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The switches do not forward these frames, but use the frames to construct a loop-free path.

Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Switches might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

Spanning tree defines a tree with a root switch and a loop-free path from the root to all switches in the Layer 2 network. Spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path.

When two interfaces on a switch are part of a loop, the spanning-tree port priority and path cost settings determine which interface is put in the forwarding state and which is put in the blocking state. The port priority value represents the location of an interface in the network topology and how well it is located to pass traffic. The path cost value represents media speed.

Supported Spanning-Tree Instances

The switch supports the per-VLAN spanning tree (PVST) and a maximum of 64 spanning-tree instances. The switch also supports the PVRST, which uses RSTP to provide rapid convergence of the PVST, only if your switch in running the enhanced software image (EI). For information about the PVRST, see the "Spanning-Tree Instances Using RSTP" section on page 13-2. For information about how spanning tree interoperates with the VLAN Trunking Protocol (VTP), see the "STP Configuration Guidelines" section on page 12-11.

Bridge Protocol Data Units

The stable, active spanning-tree topology of a switched network is determined by these elements:

- The unique bridge ID (switch priority and MAC address) associated with each VLAN on each switch
- The spanning-tree path cost to the root switch
- The port identifier (port priority and MAC address) associated with each Layer 2 interface

When the switches in a network are powered up, each functions as the root switch. Each switch sends a configuration BPDU through all of its ports. The BPDUs communicate and compute the spanning-tree topology. Each configuration BPDU contains this information:

- The unique bridge ID of the switch that the sending switch identifies as the root switch
- The spanning-tree path cost to the root
- The bridge ID of the sending switch
- Message age
- The identifier of the sending interface
- Values for the hello, forward-delay, and max-age protocol timers

When a switch receives a configuration BPDU that contains *superior* information (lower bridge ID, lower path cost, and so forth), it stores the information for that port. If this BPDU is received on the root port of the switch, the switch also forwards it with an updated message to all attached LANs for which it is the designated switch.

If a switch receives a configuration BPDU that contains *inferior* information to that currently stored for that port, it discards the BPDU. If the switch is a designated switch for the LAN from which the inferior BPDU was received, it sends that LAN a BPDU containing the up-to-date information stored for that port. In this way, inferior information is discarded, and superior information is propagated on the network.

A BPDU exchange results in these actions:

- One switch in the network is elected as the root switch.
- A root port is selected for each switch (except the root switch). This port provides the best path (lowest cost) when the switch forwards packets to the root switch.
- The shortest distance to the root switch is calculated for each switch based on the path cost.
- A designated switch for each LAN segment is selected. The designated switch incurs the lowest path cost when forwarding packets from that LAN to the root switch. The port through which the designated switch is attached to the LAN is called the designated port.
- Interfaces included in the spanning-tree instance are selected. Root ports and designated ports are put in the forwarding state.
- All interfaces not included in the spanning tree are blocked.

Election of the Root Switch

All switches in the Layer 2 network participating in spanning tree gather information about other switches in the network through an exchange of BPDU data messages. This exchange of messages results in these actions:

- The election of a unique root switch for each spanning-tree instance
- The election of a designated switch for every switched LAN segment
- The removal of loops in the switched network by blocking Layer 2 interfaces connected to redundant links

For each VLAN, the switch with the highest switch priority (the lowest numerical priority value) is elected as the root switch. If all switches are configured with the default priority (32768), the switch with the lowest MAC address in the VLAN becomes the root switch. The switch priority value occupies the most significant bits of the bridge ID.

When you change the switch priority value, you change the probability that the switch will be elected as the root switch. Configuring a higher value decreases the probability; a lower value increases the probability.

The root switch is the logical center of the spanning-tree topology in a switched network. All paths that are not needed to reach the root switch from anywhere in the switched network are placed in the spanning-tree blocking mode.

BPDUs contain information about the sending switch and its ports, including switch and MAC addresses, switch priority, port priority, and path cost. Spanning tree uses this information to elect the root switch and root port for the switched network and the root port and designated port for each switched segment.

Bridge ID, Switch Priority, and Extended System ID

The IEEE 802.1D standard requires that each switch has an unique bridge identifier (bridge ID), which determines the selection of the root switch. Because each VLAN is considered as a different *logical bridge* with PVST and PVRST, the same switch must have as many different bridge IDs as VLANs configured on it. Each VLAN on the switch has a unique 8-byte bridge ID; the two most-significant bytes are used for the switch priority, and the remaining six bytes are derived from the switch MAC address.

In Release 12.1(9)EA1 and later, Catalyst 2950 and Catalyst 2955 switches support the 802.1T spanning-tree extensions. Some of the bits previously used for the switch priority are now used as the VLAN identifier. The result is that fewer MAC addresses are reserved for the switch, and a larger range of VLAN IDs can be supported, all while maintaining the uniqueness of the bridge ID. As shown in Table 12-1, the two bytes previously used for the switch priority are reallocated into a 4-bit priority value and a 12-bit extended system ID value equal to the VLAN ID. In earlier releases, the switch priority is a 16-bit value.

Table 12-1 Switch Priority Value and Extended System ID

Switch Priority Value				Extended System ID (Set Equal to the VLAN ID)											
Bit 16	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Spanning tree uses the extended system ID, the switch priority, and the allocated spanning-tree MAC address to make the bridge ID unique for each VLAN. With earlier releases, spanning tree used one MAC address per VLAN to make the bridge ID unique for each VLAN.

Support for the extended system ID affects how you manually configure the root switch, the secondary root switch, and the switch priority of a VLAN. For more information, see the "Configuring the Root Switch" section on page 12-12, "Configuring a Secondary Root Switch" section on page 12-14, and "Configuring the Switch Priority of a VLAN" section on page 12-18.

Spanning-Tree Timers

Table 12-2 describes the timers that affect the entire spanning-tree performance.

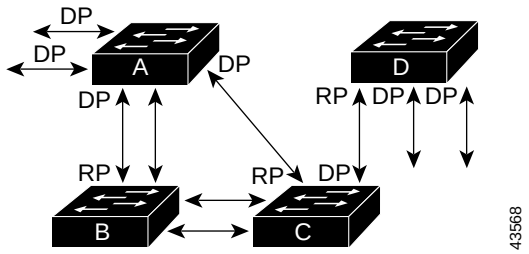
Table 12-2 Spanning-Tree Timers

Variable	Description
Hello timer	Determines how often the switch broadcasts hello messages to other switches.
Forward-delay timer	Determines how long each of the listening and learning states last before the interface begins forwarding.
Maximum-age timer	Determines the amount of time the switch stores protocol information received on an interface.

Creating the Spanning-Tree Topology

In Figure 12-1, Switch A is elected as the root switch because the switch priority of all the switches is set to the default (32768) and Switch A has the lowest MAC address. However, because of traffic patterns, number of forwarding interfaces, or link types, Switch A might not be the ideal root switch. By increasing the priority (lowering the numerical value) of the ideal switch so that it becomes the root switch, you force a spanning-tree recalculation to form a new topology with the ideal switch as the root.

Figure 12-1 Spanning-Tree Topology



RP = Root Port
DP = Designated Port

When the spanning-tree topology is calculated based on default parameters, the path between source and destination end stations in a switched network might not be ideal. For instance, connecting higher-speed links to an interface that has a higher number than the root port can cause a root-port change. The goal is to make the fastest link the root port.

For example, assume that one port on Switch B is a Gigabit Ethernet link and that another port on Switch B (a 10/100 link) is the root port. Network traffic might be more efficient over the Gigabit Ethernet link. By changing the spanning-tree port priority on the Gigabit Ethernet interface to a higher priority (lower numerical value) than the root port, the Gigabit Ethernet interface becomes the new root port.

Spanning-Tree Interface States

Propagation delays can occur when protocol information passes through a switched LAN. As a result, topology changes can take place at different times and at different places in a switched network. When an interface transitions directly from nonparticipation in the spanning-tree topology to the forwarding state, it can create temporary data loops. Interfaces must wait for new topology information to propagate through the switched LAN before starting to forward frames. They must allow the frame lifetime to expire for forwarded frames that have used the old topology.

Each Layer 2 interface on a switch using spanning tree exists in one of these states:

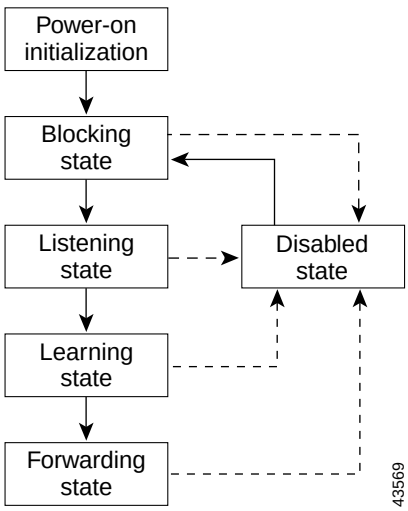
- Blocking—The interface does not participate in frame forwarding.
- Listening—The first transitional state after the blocking state when the spanning tree determines that the interface should participate in frame forwarding.
- Learning—The interface prepares to participate in frame forwarding.
- Forwarding—The interface forwards frames.
- Disabled—The interface is not participating in spanning tree because of a shutdown port, no link on the port, or no spanning-tree instance running on the port.

An interface moves through these states:

- From initialization to blocking
- From blocking to listening or to disabled
- From listening to learning or to disabled
- From learning to forwarding or to disabled
- From forwarding to disabled

Figure 12-2 illustrates how an interface moves through the states.

Figure 12-2 Spanning-Tree Interface States



When you power up the switch, STP is enabled by default, and every interface in the switch, VLAN, or network goes through the blocking state and the transitory states of listening and learning. Spanning tree stabilizes each interface at the forwarding or blocking state.

When the spanning-tree algorithm places a Layer 2 interface in the forwarding state, this process occurs:

1. The interface is in the listening state while spanning tree waits for protocol information to transition the interface to the blocking state.
2. While spanning tree waits the forward-delay timer to expire, it moves the interface to the learning state and resets the forward-delay timer.
3. In the learning state, the interface continues to block frame forwarding as the switch learns end-station location information for the forwarding database.
4. When the forward-delay timer expires, spanning tree moves the interface to the forwarding state, where both learning and frame forwarding are enabled.

Blocking State

A Layer 2 interface in the blocking state does not participate in frame forwarding. After initialization, a BPDU is sent to each interface in the switch. A switch initially functions as the root until it exchanges BPDUs with other switches. This exchange establishes which switch in the network is the root or root switch. If there is only one switch in the network, no exchange occurs, the forward-delay timer expires, and the interfaces move to the listening state. An interface always enters the blocking state after switch initialization.

An interface in the blocking state performs as follows:

- Discards frames received on the port
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

Listening State

The listening state is the first state a Layer 2 interface enters after the blocking state. The interface enters this state when the spanning tree determines that the interface should participate in frame forwarding.

An interface in the listening state performs as follows:

- Discards frames received on the port
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

Learning State

A Layer 2 interface in the learning state prepares to participate in frame forwarding. The interface enters the learning state from the listening state.

An interface in the learning state performs as follows:

- Discards frames received on the port
- Discards frames switched from another interface for forwarding
- Learns addresses
- Receives BPDUs

Forwarding State

A Layer 2 interface in the forwarding state forwards frames. The interface enters the forwarding state from the learning state.

An interface in the forwarding state performs as follows:

- Receives and forwards frames received on the port
- Forwards frames switched from another port
- Learns addresses
- Receives BPDUs

Disabled State

A Layer 2 interface in the disabled state does not participate in frame forwarding or in the spanning tree. An interface in the disabled state is nonoperational.

A disabled interface performs as follows:

- Discards frames received on the port
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Does not receive BPDUs

Spanning-Tree Address Management

IEEE 802.1D specifies 17 multicast addresses, ranging from 0x00180C2000000 to 0x0180C2000010, to be used by different bridge protocols. These addresses are static addresses that cannot be removed.

Regardless of the spanning-tree state, the switch receives but does not forward packets destined for addresses between 0x0180C2000000 and 0x0180C200000F.

If STP is enabled, the switch CPU receives packets destined for 0x0180C2000000 and 0x0180C2000010. If STP is disabled, the switch forwards those packets as unknown multicast addresses.

STP and IEEE 802.1Q Trunks

The IEEE 802.1Q standard for VLAN trunks imposes some limitations on the spanning-tree strategy for a network. The standard requires only one spanning-tree instance for *all* VLANs allowed on the trunks. However, in a network of Cisco switches connected through 802.1Q trunks, the switches maintain one spanning-tree instance for *each* VLAN allowed on the trunks.

When you connect a Cisco switch to a non-Cisco device through an 802.1Q trunk, the Cisco switch uses per-VLAN spanning tree (PVST) to provide spanning-tree interoperability. If per-VLAN rapid spanning tree (PVRST) is enabled, the switch uses PVRST instead of PVST to provide spanning-tree interoperability. The switch combines the spanning-tree instance of the 802.1Q VLAN of the trunk with the spanning-tree instance of the non-Cisco 802.1Q switch.

However, all PVST or PVRST information is maintained by Cisco switches separated by a cloud of non-Cisco 802.1Q switches. The non-Cisco 802.1Q cloud separating the Cisco switches is treated as a single trunk link between the switches.

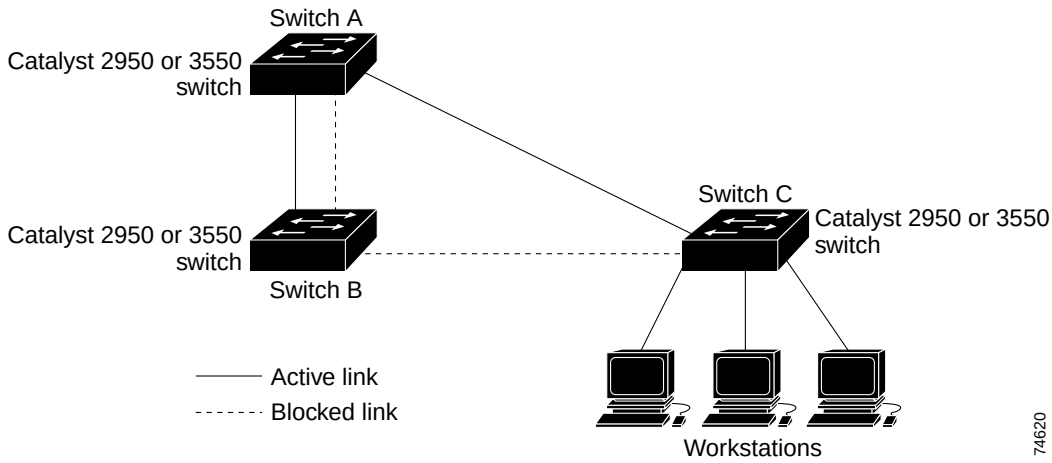
The external spanning-tree behavior on access ports and trunk ports is not affected by PVST+ or PVRST+.

For more information on 802.1Q trunks, see Chapter 15, "Configuring VLANs."

Spanning Tree and Redundant Connectivity

You can create a redundant backbone with spanning tree by connecting two switch interfaces to another device or to two different devices. Spanning tree automatically disables one interface but enables it if the other one fails, as shown in Figure 12-3. If one link is high-speed and the other is low-speed, the low-speed link is always disabled. If the speeds are the same, the port priority and port ID are added together, and spanning tree disables the link with the lowest value.

Figure 12-3 Spanning Tree and Redundant Connectivity



You can also create redundant links between switches by using EtherChannel groups. For more information, see Chapter 28, "Configuring EtherChannels."

Accelerated Aging to Retain Connectivity

The default for aging dynamic addresses is 5 minutes, the default setting of the **mac-address-table aging-time** global configuration command. However, a spanning-tree reconfiguration can cause many station locations to change. Because these stations could be unreachable for 5 minutes or more during a reconfiguration, the address-aging time is accelerated so that station addresses can be dropped from the address table and then relearned. The accelerated aging is the same as the forward-delay parameter value (**spanning-tree vlan** *vlan-id* **forward-time** *seconds* global configuration command) when the spanning tree reconfigures.

Because each VLAN is a separate spanning-tree instance, the switch accelerates aging on a per-VLAN basis. A spanning-tree reconfiguration on one VLAN can cause the dynamic addresses learned on that VLAN to be subject to accelerated aging. Dynamic addresses on other VLANs can be unaffected and remain subject to the aging interval entered for the switch.

Configuring Spanning-Tree Features

These sections describe how to configure spanning-tree features:

- Default STP Configuration, page 12-10
- STP Configuration Guidelines, page 12-11
- Disabling STP, page 12-11
- Configuring the Root Switch, page 12-12
- Configuring a Secondary Root Switch, page 12-14
- Configuring the Port Priority, page 12-15
- Configuring the Path Cost, page 12-16
- Configuring the Switch Priority of a VLAN, page 12-18
- Configuring the Hello Time, page 12-18
- Configuring the Forwarding-Delay Time for a VLAN, page 12-19
- Configuring the Maximum-Aging Time for a VLAN, page 12-20
- Configuring STP for Use in a Cascaded Stack, page 12-20

Default STP Configuration

Table 12-3 shows the default STP configuration.

Table 12-3 Default STP Configuration

Feature	Default Setting
Enable state	Enabled on VLAN 1. Up to 64 spanning-tree instances can be enabled.
Spanning-tree mode	PVST (PVRST and MSTP are disabled).
Switch priority	32768.
Spanning-tree port priority (configurable on a per-interface basis)	128.
Spanning-tree port cost (configurable on a per-interface basis)	1000 Mbps: 4. 100 Mbps: 19. 10 Mbps: 100.
Spanning-tree VLAN port priority (configurable on a per-VLAN basis)	128.
Spanning-tree VLAN port cost (configurable on a per-VLAN basis)	1000 Mbps: 4. 100 Mbps: 19. 10 Mbps: 100.
Hello time	2 seconds.
Forward-delay time	15 seconds.
Maximum-aging time	20 seconds.

STP Configuration Guidelines

If more VLANs are defined in the VTP than there are spanning-tree instances, you can enable STP on only 64 VLANs. If the number of VLANs exceeds 64, we recommend that you enable the MSTP to map multiple VLANs to a single spanning-tree instance. For more information, see the Chapter 13, "Configuring RSTP and MSTP."

If 64 instances of spanning tree are already in use, you can disable STP on one of the VLANs and then enable it on the VLAN where you want it to run. Use the **no spanning-tree vlan** *vlan-id* global configuration command to disable STP on a specific VLAN, and use the **spanning-tree vlan** *vlan-id* global configuration command to enable STP on the desired VLAN.

Caution Switches that are not running spanning tree still forward BPDUs that they receive so that the other switches on the VLAN that have a running spanning-tree instance can break loops. Therefore, spanning tree must be running on enough switches to break all the loops in the network; for example, at least one switch on each loop in the VLAN must be running spanning tree. It is not absolutely necessary to run spanning tree on all switches in the VLAN; however, if you are running spanning tree only on a minimal set of switches, an incautious change to the network that introduces another loop into the VLAN can result in a broadcast storm.

Note If you have already used all available spanning-tree instances on your switch, adding another VLAN anywhere in the VTP domain creates a VLAN that is not running spanning tree on that switch. If you have the default allowed list on the trunk ports of that switch, the new VLAN is carried on all trunk ports. Depending on the topology of the network, this could create a loop in the new VLAN that will not be broken, particularly if there are several adjacent switches that have all run out of spanning-tree instances. You can prevent this possibility by setting up allowed lists on the trunk ports of switches that have used up their allocation of spanning-tree instances. Setting up allowed lists is not necessary in many cases and can make it more labor-intensive to add another VLAN to the network.

Spanning-tree commands determine the configuration of VLAN spanning-tree instances. You create a spanning-tree instance when you assign an interface to a VLAN. The spanning-tree instance is removed when the last interface is moved to another VLAN. You can configure switch and port parameters before a spanning-tree instance is created; these parameters are applied when the spanning-tree instance is created.

Disabling STP

STP is enabled by default on VLAN 1 and on all newly created VLANs up to the spanning-tree limit specified in Table 12-3. Disable STP only if you are sure there are no loops in the network topology.

Caution When STP is disabled and loops are present in the topology, excessive traffic and indefinite packet duplication can drastically reduce network performance.

Beginning in privileged EXEC mode, follow these steps to disable STP on a per-VLAN basis:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no spanning-tree vlan** *vlan-id*	Disable STP on a per-VLAN basis. For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the enhanced software image (EI) is installed and 1 to 1005 when the standard software image (SI) is installed.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To re-enable STP, use the **spanning-tree vlan** *vlan-id* global configuration command.

Configuring the Root Switch

The switch maintains a separate spanning-tree instance for each active VLAN configured on it. A bridge ID, consisting of the switch priority and the switch MAC address, is associated with each instance. For each VLAN, the switch with the lowest bridge ID becomes the root switch for that VLAN.

To configure a switch to become the root for the specified VLAN, use the **spanning-tree vlan** *vlan-id* **root** global configuration command to modify the switch priority from the default value (32768) to a significantly lower value. When you enter this command, the switch checks the switch priority of the root switches for each VLAN. Because of the extended system ID support, the switch sets its own priority for the specified VLAN to 24576 if this value will cause this switch to become the root for the specified VLAN.

If any root switch for the specified VLAN has a switch priority lower than 24576, the switch sets its own priority for the specified VLAN to 4096 less than the lowest switch priority. (4096 is the value of the least-significant bit of a 4-bit switch priority value as shown in Table 12-1 on page 12-4.)

Note The **spanning-tree vlan** *vlan-id* **root** global configuration command fails if the value necessary to be the root switch is less than 1.

Before Release 12.1(9)EA1, entering the **spanning-tree vlan** *vlan-id* **root** global configuration command on a Catalyst 2950 switch (no extended system ID) caused it to set its own switch priority for the specified VLAN to 8192 if this value caused this switch to become the root for the specified VLAN. If any root switch for the specified VLAN has a switch priority lower than 8192, the switch sets its own priority for the specified VLAN to 1 less than the lowest switch priority.

These examples show the effect of the **spanning-tree vlan** *vlan-id* **root** command with and without the extended system ID support:

- For Catalyst 2950 and Catalyst 2955 switches with the extended system ID (Release 12.1(9)EA1 and later), if all network devices in VLAN 20 have the default priority of 32768, entering the **spanning-tree vlan 20 root primary** command on the switch sets the switch priority to 24576, which causes this switch to become the root switch for VLAN 20.
- For Catalyst 2950 switches without the extended system ID (software earlier than Release 12.1(9)EA1), if all network devices in VLAN 100 have the default priority of 32768, entering the **spanning-tree vlan 100 root primary** command on the switch sets the switch priority for VLAN 100 to 8192, which causes this switch to become the root switch for VLAN 100.

Note If your network consists of switches that both do and do not support the extended system ID, it is unlikely that the switch with the extended system ID support will become the root switch. The extended system ID increases the switch priority value every time the VLAN number is greater than the priority of the connected switches running older software.

Note The root switch for each spanning-tree instance should be a backbone or distribution switch. Do not configure an access switch as the spanning-tree primary root.

Use the **diameter** keyword to specify the Layer 2 network diameter (that is, the maximum number of switch hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

Note After configuring the switch as the root switch, we recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time by using the **spanning-tree vlan** *vlan-id* **hello-time**, **spanning-tree vlan** *vlan-id* **forward-time**, and the **spanning-tree vlan** *vlan-id* **max-age** global configuration commands.

Beginning in privileged EXEC mode, follow these steps to configure a switch to become the root for the specified VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree vlan** *vlan-id* **root primary** [**diameter** *net-diameter* [**hello-time** *seconds*]]	Configure a switch to become the root for the specified VLAN. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • (Optional) For **diameter** *net-diameter*, specify the maximum number of switches between any two end stations. The range is 2 to 7. • (Optional) For **hello-time** *seconds*, specify the interval in seconds between the generation of configuration messages by the root switch. The range is 1 to 10 seconds; the default is 2 seconds. **Note** When you enter this command without the optional keywords, the switch recalculates the **forward-time, hello-time**, **max-age**, and **priority** settings. If you had previously configured these parameters, the switch overrides and recalculates them.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree detail**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree vlan** *vlan-id* **root** global configuration command.

Configuring a Secondary Root Switch

When you configure a Catalyst 2950 or Catalyst 2955 switch that supports the extended system ID as the secondary root, the switch priority is modified from the default value (32768) to 28672. The switch is then likely to become the root switch for the specified VLAN if the primary root switch fails. This is assuming that the other network switches use the default switch priority of 32768 and therefore are unlikely to become the root switch. For Catalyst 2950 switches without the extended system ID support (software earlier than Release 12.1(9)EA1), the switch priority is changed to 16384.

You can execute this command on more than one switch to configure multiple backup root switches. Use the same network diameter and hello-time values as you used when you configured the primary root switch with the **spanning-tree vlan** *vlan-id* **root primary** global configuration command.

Beginning in privileged EXEC mode, follow these steps to configure a switch to become the secondary root for the specified VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree vlan** *vlan-id* **root secondary** [**diameter** *net-diameter* [**hello-time** *seconds*]]	Configure a switch to become the secondary root for the specified VLAN. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • (Optional) For **diameter** *net-diameter*, specify the maximum number of switches between any two end stations. The range is 2 to 7. • (Optional) For **hello-time** *seconds*, specify the interval in seconds between the generation of configuration messages by the root switch. The range is 1 to 10 seconds; the default is 2 seconds. Use the same network diameter and hello-time values that you used when configuring the primary root switch. See the "Configuring the Root Switch" section on page 12-12.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree detail**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree vlan** *vlan-id* **root** global configuration command.

Configuring the Port Priority

If a loop occurs, spanning tree uses the port priority when selecting an interface to put into the forwarding state. You can assign higher priority values (lower numerical values) to interfaces that you want selected first and lower priority values (higher numerical values) that you want selected last. If all interfaces have the same priority value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

Beginning in privileged EXEC mode, follow these steps to configure the port priority of an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify an interface to configure. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*).

	Command	Purpose
Step 3	**spanning-tree port-priority** *priority*	Configure the port priority for an interface. For *priority*, the range is 0 to 240 in increments of 16. The default is 128. The lower the number, the higher the priority. Valid priority values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected.
Step 4	**spanning-tree vlan** *vlan-id* **port-priority** *priority*	Configure the VLAN port priority for an interface. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. For *priority*,the range is 0 to 240 in increments of 16. The default is 128. The lower the number, the higher the priority. Valid priority values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show spanning-tree interface** *interface-id* or **show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note The **show spanning-tree interface** *interface-id* privileged EXEC command displays information only if the port is in a link-up operative state. Otherwise, you can use the **show running-config interface** privileged EXEC command to confirm the configuration.

To return the interface to its default setting, use the **no spanning-tree** [**vlan** *vlan-id*] **port-priority** interface configuration command. For information on how to configure load sharing on trunk ports by using spanning-tree port priorities, see the "Load Sharing Using STP" section on page 15-21.

Configuring the Path Cost

The spanning-tree path cost default value is derived from the media speed of an interface. If a loop occurs, spanning tree uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all interfaces have the same cost value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

Beginning in privileged EXEC mode, follow these steps to configure the cost of an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify an interface to configure. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*).
Step 3	**spanning-tree cost** *cost*	Configure the cost for an interface. If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. For *cost*, the range is 1 to 200000000; the default value is derived from the media speed of the interface.
Step 4	**spanning-tree vlan** *vlan-id* **cost** *cost*	Configure the cost for a VLAN. If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • For *cost*, the range is 1 to 200000000; the default value is derived from the media speed of the interface.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show spanning-tree interface** *interface-id* or **show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note The **show spanning-tree interface** *interface-id* privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

To return the interface to its default setting, use the **no spanning-tree** [**vlan** *vlan-id*] **cost** interface configuration command. For information on how to configure load sharing on trunk ports by using spanning-tree path costs, see the "Load Sharing Using STP" section on page 15-21.

Configuring the Switch Priority of a VLAN

You can configure the switch priority and make it more likely that the switch will be chosen as the root switch.

Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree vlan** *vlan-id* **root primary** and the **spanning-tree vlan** *vlan-id* **root secondary** global configuration commands to modify the switch priority.

Beginning in privileged EXEC mode, follow these steps to configure the switch priority of a VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree vlan** *vlan-id* **priority** *priority*	Configure the switch priority of a VLAN. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • For *priority*, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the switch will be chosen as the root switch. Valid priority values are 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. All other values are rejected.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree vlan** *vlan-id* **priority** global configuration command.

Configuring the Hello Time

You can configure the interval between the generation of configuration messages by the root switch by changing the hello time.

Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree vlan** *vlan-id* **root primary** and the **spanning-tree vlan** *vlan-id* **root secondary** global configuration commands to modify the hello time.

Beginning in privileged EXEC mode, follow these steps to configure the hello time of a VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree vlan** *vlan-id* **hello-time** *seconds*	Configure the hello time of a VLAN. The hello time is the interval between the generation of configuration messages by the root switch. These messages mean that the switch is alive. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • For *seconds*, the range is 1 to 10; the default is 2.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree vlan** *vlan-id* **hello-time** global configuration command.

Configuring the Forwarding-Delay Time for a VLAN

Beginning in privileged EXEC mode, follow these steps to configure the forwarding-delay time for a VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree vlan** *vlan-id* **forward-time** *seconds*	Configure the forward time of a VLAN. The forward delay is the number of seconds a port waits before changing from its spanning-tree learning and listening states to the forwarding state. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • For *seconds*, the range is 4 to 30; the default is 15.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree vlan** *vlan-id* **forward-time** global configuration command.

Configuring the Maximum-Aging Time for a VLAN

Beginning in privileged EXEC mode, follow these steps to configure the maximum-aging time for a VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree vlan** *vlan-id* **max-age** *seconds*	Configure the maximum-aging time of a VLAN. The maximum-aging time is the number of seconds a switch waits without receiving spanning-tree configuration messages before attempting a reconfiguration. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. • For *seconds*, the range is 6 to 40; the default is 20.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree vlan** *vlan-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree vlan** *vlan-id* **max-age** global configuration command.

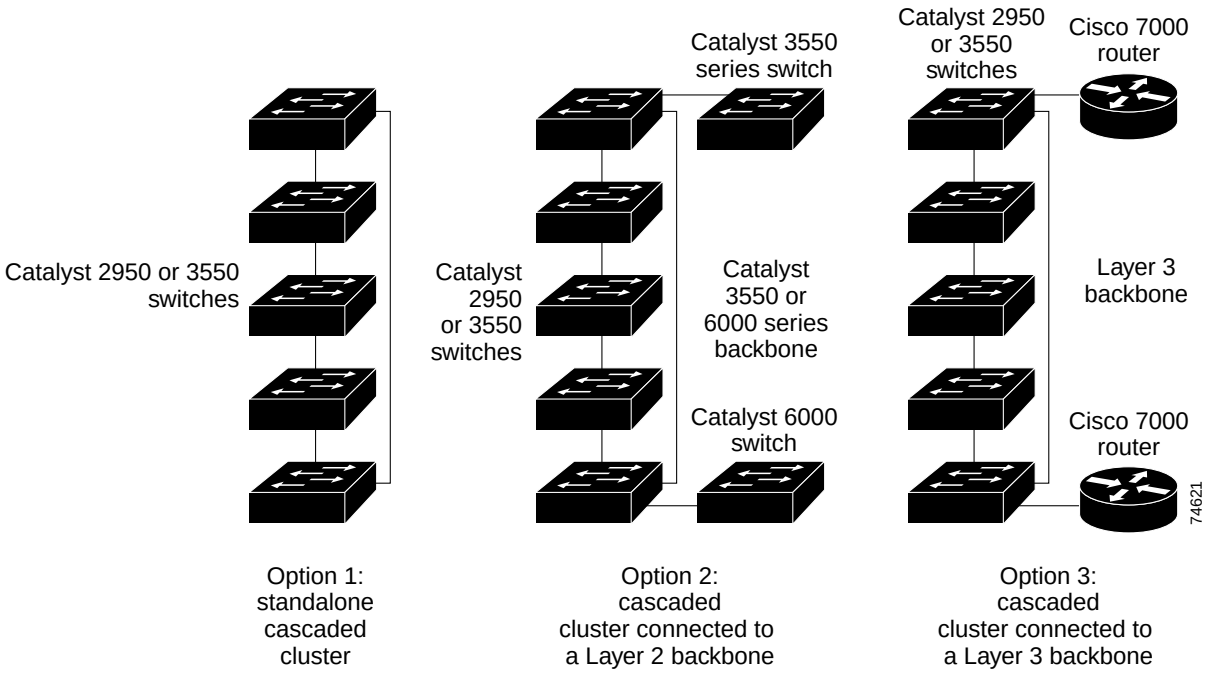
Configuring STP for Use in a Cascaded Stack

STP uses default values that can be reduced when configuring your switch in cascaded configurations. If a root switch is part of a cluster that is one switch from a cascaded stack, you can customize spanning tree to reconverge more quickly after a switch failure. Figure 12-4 shows switches in three cascaded stacks that use the GigaStack GBIC. Table 12-4 shows the default STP settings and those that are acceptable for these configurations.

Table 12-4 Default and Acceptable STP Parameter Settings (in seconds)

STP Parameter	STP Default	Acceptable for Option 1	Acceptable for Option 2	Acceptable for Option 3
Hello Time	2	1	1	1
Max Age	20	6	10	6
Forwarding Delay	15	4	7	4

Figure 12-4 Gigabit Ethernet Stack


Catalyst 2950 or 3550 switches
Catalyst 3550 series switch
Catalyst 2950 or 3550 switches
Cisco 7000 router
Catalyst 2950 or 3550 switches
Catalyst 3550 or 6000 series backbone
Layer 3 backbone
Catalyst 6000 switch
Cisco 7000 router
74621
Option 1: standalone cascaded cluster
Option 2: cascaded cluster connected to a Layer 2 backbone
Option 3: cascaded cluster connected to a Layer 3 backbone

Displaying the Spanning-Tree Status

To display the spanning-tree status, use one or more of the privileged EXEC commands in Table 12-5:

Table 12-5 Commands for Displaying Spanning-Tree Status

Command	Purpose
show spanning-tree active	Displays spanning-tree information on active interfaces only.
show spanning-tree detail	Displays a detailed summary of interface information.
show spanning-tree interface *interface-id*	Displays spanning-tree information for the specified interface.
show spanning-tree summary [**totals**]	Displays a summary of port states or displays the total lines of the STP state section.

For information about other keywords for the **show spanning-tree** privileged EXEC command, refer to the command reference for this release.

CHAPTER 13

Configuring RSTP and MSTP

This chapter describes how to configure the Cisco implementation of the IEEE 802.1W Rapid Spanning Tree Protocol (RSTP) and the IEEE 802.1S Multiple STP (MSTP) on your Catalyst 2950 or Catalyst 2955 switch. It also describes how to configure per-VLAN rapid spanning tree (PVRST). To use the features described in this chapter, you must have the enhanced software image (EI) installed on your switch.

RSTP provides rapid convergence of the spanning tree. MSTP, which uses RSTP to provide rapid convergence, enables VLANs to be grouped into a spanning-tree instance, provides for multiple forwarding paths for data traffic, and enables load balancing. It improves the fault tolerance of the network because a failure in one instance (forwarding path) does not affect other instances (forwarding paths). The most common initial deployment of MSTP and RSTP is in the backbone and distribution layers of a Layer 2 switched network; this deployment provides the highly-available network required in a service-provider environment.

Both RSTP and MSTP improve the operation of the spanning tree while maintaining backward compatibility with equipment that is based on the (original) 802.1D spanning tree, with existing Cisco per-VLAN spanning tree (PVST), and with the existing Cisco-proprietary Multiple Instance STP (MISTP). For information about STP, see Chapter 12, “Configuring STP.” For information about optional spanning-tree features, see Chapter 14, “Configuring Optional Spanning-Tree Features.”

PVRST uses RSTP to provide rapid convergence of spanning-tree instances. PVRST also maintains backward compatibility with equipment that is based on the 802.1D spanning tree, with PVST and MISTP. You can use this feature on a switch running MSTP. For information about PVRST, see the “Spanning-Tree Instances Using RSTP” section on page 13-2.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding RSTP, page 13-2
- Understanding MSTP, page 13-7
- Interoperability with 802.1D STP, page 13-11
- Configuring RSTP and MSTP Features, page 13-11
- Displaying the MST Configuration and Status, page 13-23

Understanding RSTP

The RSTP takes advantage of point-to-point wiring and provides rapid convergence of the spanning tree. Reconfiguration of the spanning tree can occur in less than 1 second (in contrast to 50 seconds with the default settings in the 802.1D spanning tree), which is critical for networks carrying delay-sensitive traffic such as voice and video.

These section describes how the RSTP works:

- Spanning-Tree Instances Using RSTP, page 13-2
- Port Roles and the Active Topology, page 13-2
- Rapid Convergence, page 13-3
- Synchronization of Port Roles, page 13-4
- Bridge Protocol Data Unit Format and Processing, page 13-5

For configuration information, see the "Configuring RSTP and MSTP Features" section on page 13-11.

Spanning-Tree Instances Using RSTP

The switch supports the PVRST and a maximum of 64 spanning-tree instances. When PVRST is enabled, the switch uses RSTP instead of STP to provide faster convergence. For information about the PVST, see the "Supported Spanning-Tree Instances" section on page 12-2. For information about how spanning tree interoperates with the VLAN Trunking Protocol (VTP), see the "STP Configuration Guidelines" section on page 12-11.

When a network contains switches running PVRST and switches running PVST, we recommend that the PVRST switches and PVST switches be in different spanning-tree instances. In the PVRST spanning-tree instances, the root switch must be a PVRST switch. In the PVST instances, the root switch must be a PVST switch. The PVST switches should be at the edge of the network.

Port Roles and the Active Topology

The RSTP provides rapid convergence of the spanning tree by assigning port roles and by determining the active topology. The RSTP builds upon the IEEE 802.1D STP to select the switch with the highest switch priority (lowest numerical priority value) as the root switch as described in "Election of the Root Switch" section on page 12-3. Then the RSTP assigns one of these port roles to individual ports:

- Root port—Provides the best path (lowest cost) when the switch forwards packets to the root switch.
- Designated port—Connects to the designated switch, which incurs the lowest path cost when forwarding packets from that LAN to the root switch. The port through which the designated switch is attached to the LAN is called the designated port.
- Alternate port—Offers an alternate path toward the root switch to that provided by the current root port.
- Backup port—Acts as a backup for the path provided by a designated port toward the leaves of the spanning tree. A backup port can exist only when two ports are connected together in a loopback by a point-to-point link or when a switch has two or more connections to a shared LAN segment.
- Disabled port—Has no role within the operation of the spanning tree.

A port with the root or a designated port role is included in the active topology. A port with the alternate or backup port role is excluded from the active topology.

In a stable topology with consistent port roles throughout the network, the RSTP ensures that every root port and designated port immediately transition to the forwarding state while all alternate and backup ports are always in the discarding state (equivalent to blocking in 802.1D). The port state controls the operation of the forwarding and learning processes. Table 13-1 provides a comparison of 802.1D and RSTP port states.

Table 13-1 Port State Comparison

Operational Status	STP Port State	RSTP Port State	Is Port Included in the Active Topology?
Enabled	Blocking	Discarding	No
Enabled	Listening	Discarding	No
Enabled	Learning	Learning	Yes
Enabled	Forwarding	Forwarding	Yes
Disabled	Disabled	Discarding	No

To be consistent with Cisco STP implementations, this guide documents the port state as *blocking* instead of *discarding*. Designated ports start in the listening state.

Rapid Convergence

The RSTP provides for rapid recovery of connectivity following the failure of a switch, a switch port, or a LAN. It provides rapid convergence for edge ports, new root ports, and ports connected through point-to-point links as follows:

- Edge ports—If you configure a port as an edge port on an RSTP switch by using the **spanning-tree portfast** interface configuration command, the edge port immediately transitions to the forwarding state. An edge port is the same as a Port Fast-enabled port, and you should enable it only on ports that connect to a single end station.
- Root ports—If the RSTP selects a new root port, it blocks the old root port and immediately transitions the new root port to the forwarding state.
- Point-to-point links—If you connect a port to another port through a point-to-point link and the local port becomes a designated port, it negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology.

  As shown in Figure 13-1, Switch A is connected to Switch B through a point-to-point link, and all of the ports are in the blocking state. Assume that the priority of Switch A is a smaller numerical value than the priority of Switch B. Switch A sends a proposal message (a configuration bridge protocol data unit [BPDU] with the proposal flag set) to Switch B, proposing itself as the designated switch.

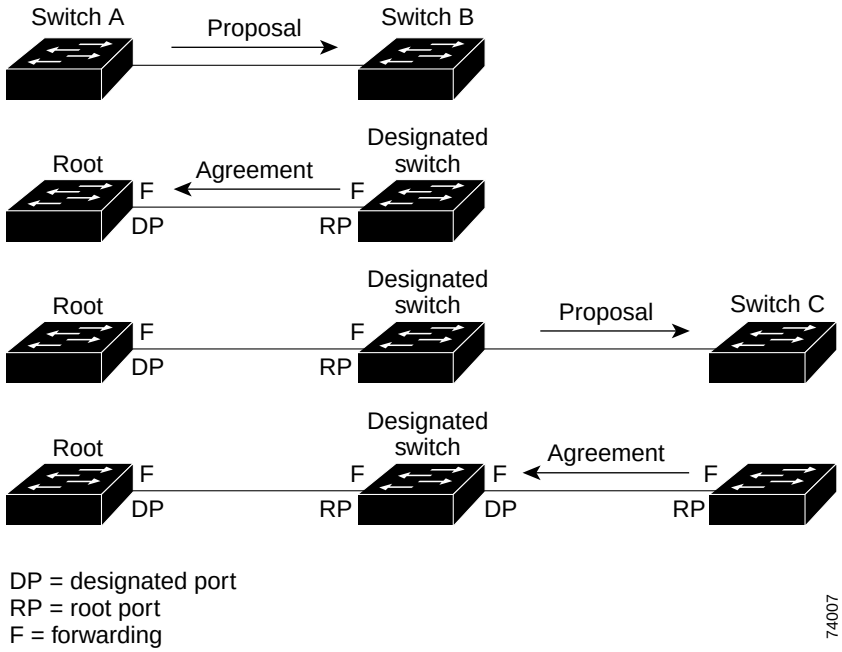
  After receiving the proposal message, Switch B selects as its new root port the port from which the proposal message was received, forces all nonedge ports to the blocking state, and sends an agreement message (a BPDU with the agreement flag set) through its new root port.

  After receiving Switch B's agreement message, Switch A also immediately transitions its designated port to the forwarding state. No loops in the network are formed because Switch B blocked all of its nonedge ports and because there is a point-to-point link between Switches A and B.

When Switch C is connected to Switch B, a similar set of handshaking messages are exchanged. Switch C selects the port connected to Switch B as its root port, and both ends immediately transition to the forwarding state. With each iteration of this handshaking process, one more switch joins the active topology. As the network converges, this proposal-agreement handshaking progresses from the root toward the leaves of the spanning tree.

The switch determines the link type from the port duplex mode: a full-duplex port is considered to have a point-to-point connection; a half-duplex port is considered to have a shared connection. You can override the default setting that is determined by the duplex setting by using the **spanning-tree link-type** interface configuration command.

Figure 13-1 Proposal and Agreement Handshaking for Rapid Convergence



Synchronization of Port Roles

When the switch receives a proposal message on one of its ports and that port is selected as the new root port, the RSTP forces all other ports to synchronize with the new root information.

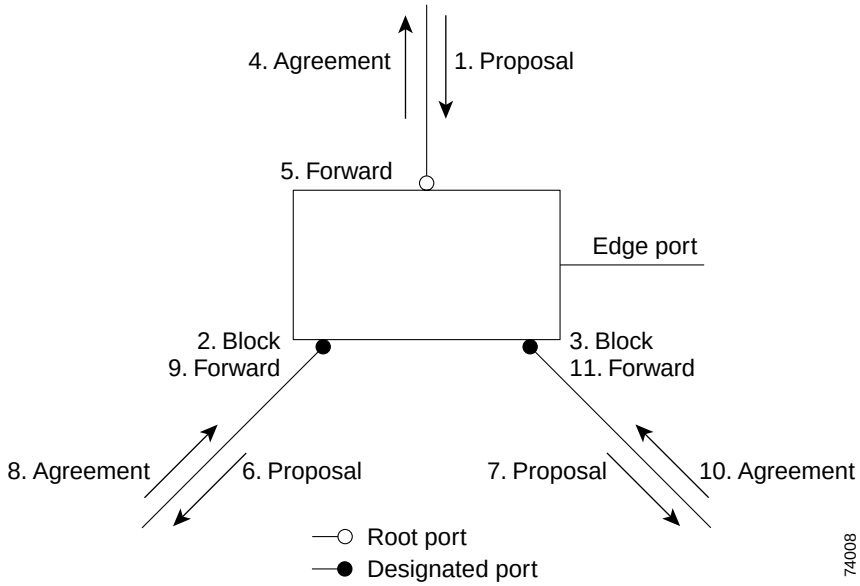
The switch is synchronized with superior root information received on the root port if all other ports are synchronized. An individual port on the switch is synchronized if

- That port is in the blocking state
- It is an edge port (a port configured to be at the edge of the network)

If a designated port is in the forwarding state and is not configured as an edge port, it transitions to the blocking state when the RSTP forces it to synchronize with new root information. In general, when the RSTP forces a port to synchronize with root information and the port does not satisfy any of the above conditions, its port state is set to blocking.

After ensuring all of the ports are synchronized, the switch sends an agreement message to the designated switch corresponding to its root port. When the switches connected by a point-to-point link are in agreement about their port roles, the RSTP immediately transitions the port states to forwarding. The sequence of events is shown in Figure 13-2.

Figure 13-2 Sequence of Events During Rapid Convergence



Bridge Protocol Data Unit Format and Processing

The RSTP BPDU format is the same as the IEEE 802.1D BPDU format except that the protocol version is set to 2. A new one-byte version 1 Length field is set to zero, which means that no version 1 protocol information is present. Table 13-2 shows the RSTP flag fields.

Table 13-2 RSTP BPDU Flags

Bit	Function
0	Topology change (TC)
1	Proposal
2–3:	Port role:
00	Unknown
01	Alternate port
10	Root port
11	Designated port
4	Learning
5	Forwarding
6	Agreement
7	Topology change acknowledgement (TCA)

The sending switch sets the proposal flag in the RSTP BPDU to propose itself as the designated switch on that LAN. The port role in the proposal message is always set to the designated port.

The sending switch sets the agreement flag in the RSTP BPDU to accept the previous proposal. The port role in the agreement message is always set to the root port.

The RSTP does not have a separate topology change notification (TCN) BPDU. It uses the topology change (TC) flag to show the topology changes. However, for interoperability with 802.1D switches, the RSTP switch processes and generates TCN BPDUs.

The learning and forwarding flags are set according to the state of the sending port.

Processing Superior BPDU Information

If a port receives superior root information (lower bridge ID, lower path cost, and so forth) than currently stored for the port, the RSTP triggers a reconfiguration. If the port is proposed and is selected as the new root port, RSTP forces all the other ports to synchronize.

If the BPDU received is an RSTP BPDU with the proposal flag set, the switch sends an agreement message after all of the other ports are synchronized. If the BPDU is an 802.1D BPDU, the switch does not set the proposal flag and starts the forward-delay timer for the port. The new root port requires twice the forward-delay time to transition to the forwarding state.

If the superior information received on the port causes the port to become a backup or alternate port, RSTP sets the port to the blocking state but does not send the agreement message. The designated port continues sending BPDUs with the proposal flag set until the forward-delay timer expires, at which time the port transitions to the forwarding state.

Processing Inferior BPDU Information

If a designated port receives an inferior BPDU (higher bridge ID, higher path cost, and so forth than currently stored for the port) with a designated port role, it immediately replies with its own information.

Topology Changes

This section describes the differences between the RSTP and the 802.1D in handling spanning-tree topology changes.

- Detection—Unlike 802.1D in which *any* transition between the blocking and the forwarding state causes a topology change, *only* transitions from the blocking to the forwarding state cause a topology change with RSTP (only an increase in connectivity is considered a topology change). State changes on an edge port do not cause a topology change. When an RSTP switch detects a topology change, it flushes the learned information on all of its nonedge ports except on those from which it received the TC notification.
- Notification—Unlike 802.1D, which uses TCN BPDUs, the RSTP does not use them. However, for 802.1D interoperability, an RSTP switch processes and generates TCN BPDUs.
- Acknowledgement—When an RSTP switch receives a TCN message on a designated port from an 802.1D switch, it replies with an 802.1D configuration BPDU with the TCA bit set. However, if the TC-while timer (the same as the topology-change timer in 802.1D) is active on a root port connected to an 802.1D switch and a configuration BPDU with the TCA bit set is received, the TC-while timer is reset.

  This behavior is only required to support 802.1D switches. The RSTP BPDUs never have the TCA bit set.

- Propagation—When an RSTP switch receives a TC message from another switch through a designated or root port, it propagates the change to all of its nonedge, designated ports and to the root port (excluding the port on which it is received). The switch starts the TC-while timer for all such ports and flushes the information learned on them.
- Protocol migration—For backward compatibility with 802.1D switches, RSTP selectively sends 802.1D configuration BPDUs and TCN BPDUs on a per-port basis.

  When a port is initialized, the migrate-delay timer is started (specifies the minimum time during which RSTP BPDUs are sent), and RSTP BPDUs are sent. While this timer is active, the switch processes all BPDUs received on that port and ignores the protocol type.

  If the switch receives an 802.1D BPDU after the port's migration-delay timer has expired, it assumes that it is connected to an 802.1D switch and starts using only 802.1D BPDUs. However, if the RSTP switch is using 802.1D BPDUs on a port and receives an RSTP BPDU after the timer has expired, it restarts the timer and starts using RSTP BPDUs on that port.

Understanding MSTP

MSTP, which uses RSTP for rapid convergence, enables VLANs to be grouped into a spanning-tree instance, with each instance having a spanning-tree topology independent of other spanning-tree instances. This architecture provides multiple forwarding paths for data traffic, enables load balancing, and reduces the number of spanning-tree instances required to support a large number of VLANs.

These sections describe how the MSTP works:

- Multiple Spanning-Tree Regions, page 13-7
- IST, CIST, and CST, page 13-8
- Hop Count, page 13-10
- Boundary Ports, page 13-10

For configuration information, see the "Configuring RSTP and MSTP Features" section on page 13-11.

Multiple Spanning-Tree Regions

For switches to participate in multiple spanning-tree (MST) instances, you must consistently configure the switches with the same MST configuration information. A collection of interconnected switches that have the same MST configuration comprises an MST region as shown in Figure 13-3 on page 13-9.

The MST configuration determines to which MST region each switch belongs. The configuration includes the name of the region, the revision number, and the MST instance-to-VLAN assignment map. You configure the switch for a region by using the **spanning-tree mst configuration** global configuration command, after which the switch enters the MST configuration mode. From this mode, you can map VLANs to an MST instance by using the **instance** MST configuration command, specify the region name by using the **name** MST configuration command, and set the revision number by using the **revision** MST configuration command.

A region can have one member or multiple members with the same MST configuration; each member must be capable of processing RSTP BPDUs. There is no limit to the number of MST regions in a network, but each region can support up to 16 spanning-tree instances. You can assign a VLAN to only one spanning-tree instance at a time.

IST, CIST, and CST

Unlike PVST and PVRST in which all the spanning-tree instances are independent, the MSTP establishes and maintains two types of spanning-trees:

- An internal spanning tree (IST), which is the spanning tree that runs in an MST region.

  Within each MST region, the MSTP maintains multiple spanning-tree instances. Instance 0 is a special instance for a region, known as the internal spanning tree (IST). All other MST instances are numbered from 1 to 15.

  The IST is the only spanning-tree instance that sends and receives BPDUs; all of the other spanning-tree instance information is contained in M-records, which are encapsulated within MSTP BPDUs. Because the MSTP BPDU carries information for all instances, the number of BPDUs that need to be processed by a switch to support multiple spanning-tree instances is significantly reduced.

  All MST instances within the same region share the same protocol timers, but each MST instance has its own topology parameters, such as root switch ID, root path cost, and so forth. By default, all VLANs are assigned to the IST.

  An MST instance is local to the region; for example, MST instance 1 in region A is independent of MST instance 1 in region B, even if regions A and B are interconnected.

- A common and internal spanning tree (CIST), which is a collection of the ISTs in each MST region, and the common spanning tree (CST) that interconnects the MST regions and single spanning trees.

  The spanning tree computed in a region appears as a subtree in the CST that encompasses the entire switched domain. The CIST is formed as a result of the spanning-tree algorithm running between switches that support the 802.1W, 802.1S, and 802.1D protocols. The CIST inside an MST region is the same as the CST outside a region.

For more information, see the "Operations Within an MST Region" section on page 13-8 and the "Operations Between MST Regions" section on page 13-9.

Operations Within an MST Region

The IST connects all the MSTP switches in a region. When the IST converges, the root of the IST becomes the IST master (shown in Figure 13-3 on page 13-9), which is the switch within the region with the lowest bridge ID and path cost to the CST root. The IST master also is the CST root if there is only one region within the network. If the CST root is outside the region, one of the MSTP switches at the boundary of the region is selected as the IST master.

When an MSTP switch initializes, it sends BPDUs claiming itself as the root of the CST and the IST master, with both of the path costs to the CST root and to the IST master set to zero. The switch also initializes all of its MST instances and claims to be the root for all of them. If the switch receives superior MST root information (lower bridge ID, lower path cost, and so forth) than currently stored for the port, it relinquishes its claim as the IST master.

During initialization, a region might have many subregions, each with its own IST master. As switches receive superior IST information, they leave their old subregions and join the new subregion that might contain the true IST master. Thus all subregions shrink, except for the one that contains the true IST master.

For correct operation, all switches in the MST region must agree on the same IST master. Therefore, any two switches in the region synchronize their port roles for an MST instance only if they converge to a common IST master.

Operations Between MST Regions

If there are multiple regions or legacy 802.1D switches within the network, MSTP establishes and maintains the CST, which includes all MST regions and all legacy STP switches in the network. The MST instances combine with the IST at the boundary of the region to become the CST.

The IST connects all the MSTP switches in the region and appears as a subtree in the CST that encompasses the entire switched domain, with the root of the subtree being the IST master. The MST region appears as a virtual switch to adjacent STP switches and MST regions.

Figure 13-3 shows a network with three MST regions and a legacy 802.1D switch (D). The IST master for region 1 (A) is also the CST root. The IST master for region 2 (B) and the IST master for region 3 (C) are the roots for their respective subtrees within the CST. The RSTP runs in all regions.

Figure 13-3 MST Regions, IST Masters, and the CST Root

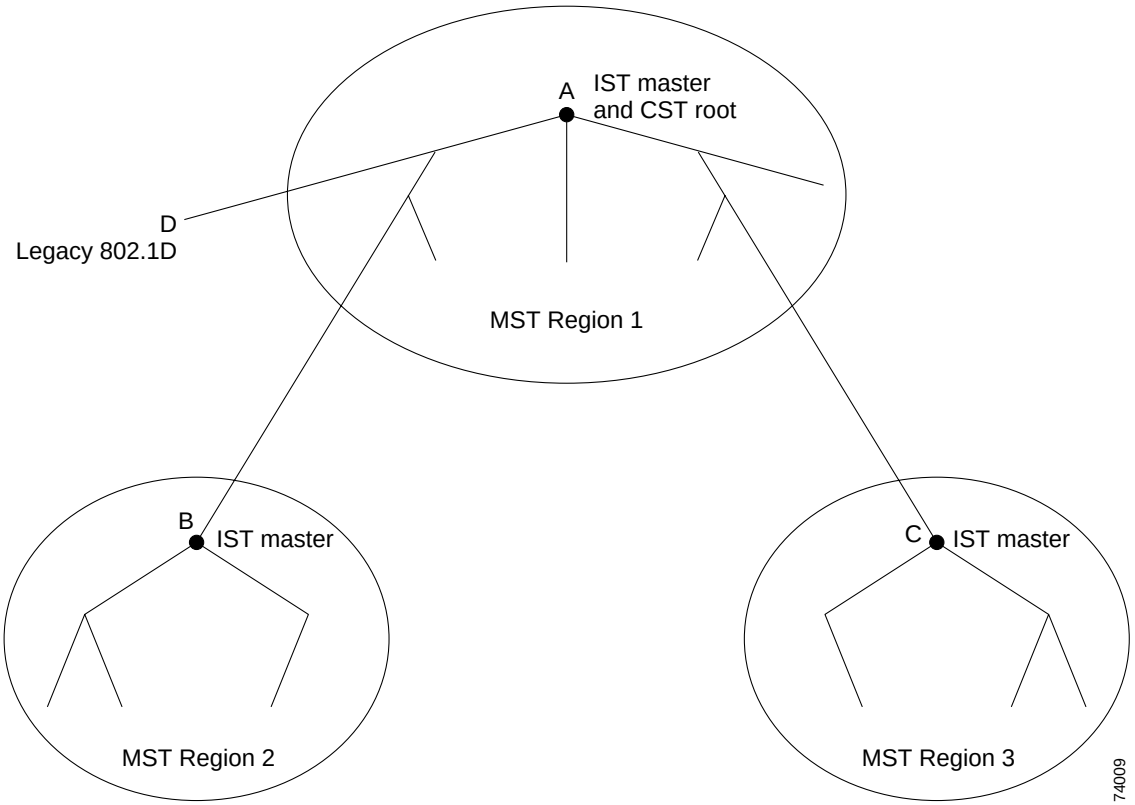


Figure 13-3 does not show additional MST instances for each region. Note that the topology of MST instances can be different from that of the IST for the same region.

Only the CST instance sends and receives BPDUs, and MST instances add their spanning-tree information into the BPDUs to interact with neighboring switches and compute the final spanning-tree topology. Because of this, the spanning-tree parameters related to BPDU transmission (for example, hello time, forward time, max-age, and max-hops) are configured only on the CST instance but affect all MST instances. Parameters related to the spanning-tree topology (for example, switch priority, port VLAN cost, port VLAN priority) can be configured on both the CST instance and the MST instance.

MSTP switches use version 3 RSTP BPDUs or 802.1D STP BPDUs to communicate with legacy 802.1D switches. MSTP switches use MSTP BPDUs to communicate with MSTP switches.

Hop Count

The IST and MST instances do not use the message-age and maximum-age information in the configuration BPDU to compute the spanning-tree topology. Instead, they use the path cost to the root and a hop-count mechanism similar to the IP time-to-live (TTL) mechanism.

By using the **spanning-tree mst max-hops** global configuration command, you can configure the maximum hops inside the region and apply it to the IST and all MST instances in that region. The hop count achieves the same result as the message-age information (determines when to trigger a reconfiguration). The root switch of the instance always sends a BPDU (or M-record) with a cost of 0 and the hop count set to the maximum value. When a switch receives this BPDU, it decrements the received remaining hop count by one and propagates this value as the remaining hop count in the BPDUs it generates. When the count reaches zero, the switch discards the BPDU and ages the information held for the port.

The message-age and maximum-age information in the RSTP portion of the BPDU remain the same throughout the region, and the same values are propagated by the region's designated ports at the boundary.

Boundary Ports

A boundary port is a port that connects an MST region to a single spanning-tree region running RSTP, or to a single spanning-tree region running 802.1D, or to another MST region with a different MST configuration. A boundary port also connects to a LAN, the designated switch of which is either a single spanning-tree switch or a switch with a different MST configuration.

At the boundary, the roles of the MST ports do not matter, and their state is forced to be the same as the IST port state (MST ports at the boundary are in the forwarding state only when the IST port is forwarding). An IST port at the boundary can have any port role except a backup port role.

On a shared boundary link, the MST ports wait in the blocking state for the forward-delay time to expire before transitioning to the learning state. The MST ports wait another forward-delay time before transitioning to the forwarding state.

If the boundary port is on a point-to-point link and it is the IST root port, the MST ports transition to the forwarding state as soon as the IST port transitions to the forwarding state.

If the IST port is a designated port on a point-to-point link and if the IST port transitions to the forwarding state because of an agreement received from its peer port, the MST ports also immediately transition to the forwarding state.

If a boundary port transitions to the forwarding state in an IST instance, it is forwarding in all MST instances, and a topology change is triggered. If a boundary port with the IST root or designated port role receives a topology change notice external to the MST cloud, the MSTP switch triggers a topology change in the IST instance and in all the MST instances active on that port.

Interoperability with 802.1D STP

A switch running MSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy 802.1D switches. If this switch receives a legacy 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only 802.1D BPDUs on that port. An MSTP switch can also detect that a port is at the boundary of a region when it receives a legacy BPDU, an MSTP BPDU (version 3) associated with a different region, or an RSTP BPDU (version 2).

However, the switch does not automatically revert to the MSTP mode if it no longer receives 802.1D BPDUs because it cannot determine whether the legacy switch has been removed from the link unless the legacy switch is the designated switch. Also, a switch might continue to assign a boundary role to a port when the switch to which this switch is connected has joined the region. To restart the protocol migration process (force the renegotiation with neighboring switches), you can use the **clear spanning-tree detected-protocols** privileged EXEC command.

If all the legacy switches on the link are RSTP switches, they can process MSTP BPDUs as if they are RSTP BPDUs. Therefore, MSTP switches send either a version 0 configuration and TCN BPDUs or version 3 MSTP BPDUs on a boundary port. A boundary port connects to a LAN, the designated switch of which is either a single spanning-tree switch or a switch with a different MST configuration.

Configuring RSTP and MSTP Features

These sections describe how to configure basic RSTP and MSTP features:

- Default RSTP and MSTP Configuration, page 13-12
- RSTP and MSTP Configuration Guidelines, page 13-12
- Specifying the MST Region Configuration and Enabling MSTP, page 13-13 (required)
- Configuring the Root Switch, page 13-14 (optional)
- Configuring a Secondary Root Switch, page 13-16 (optional)
- Configuring the Port Priority, page 13-17 (optional)
- Configuring the Path Cost, page 13-18 (optional)
- Configuring the Switch Priority, page 13-19 (optional)
- Configuring the Hello Time, page 13-19 (optional)
- Configuring the Forwarding-Delay Time, page 13-20 (optional)
- Configuring the Maximum-Aging Time, page 13-21 (optional)
- Configuring the Maximum-Hop Count, page 13-21 (optional)
- Specifying the Link Type to Ensure Rapid Transitions, page 13-22 (optional)
- Restarting the Protocol Migration Process, page 13-22 (optional)

Default RSTP and MSTP Configuration

Table 13-3 shows the default RSTP and MSTP configuration.

Table 13-3 Default RSTP and MSTP Configuration

Feature	Default Setting
Spanning-tree mode	PVST (PVRST and MSTP are disabled).
Switch priority (configurable on a per-CIST interface basis)	32768.
Spanning-tree port priority (configurable on a per-CIST interface basis)	128.
Spanning-tree port cost (configurable on a per-CIST interface basis)	1000 Mbps: 4. 100 Mbps: 19. 10 Mbps: 100.
Hello time	2 seconds.
Forward-delay time	15 seconds.
Maximum-aging time	20 seconds.
Maximum hop count	20 hops.

RSTP and MSTP Configuration Guidelines

These are the configuration guidelines for RSTP and MSTP:

- The UplinkFast, BackboneFast, and cross-stack UplinkFast features are not supported with the PVRST and MSTP.
- Per-VLAN RSTP is not supported in software releases earlier than Release 12.1(13)EA1. When you enable MST by using the **spanning-tree mode mst** global configuration command, RSTP is enabled.
- Per-VLAN RSTP is supported in Release 12.1(13)EA1 or later. When you enable PVRST by using the **spanning-tree mode rapid-pvst** global configuration command, RSTP is enabled.
- PVST, PVRST, and MSTP are supported, but only one version can be active at any time; all VLANs run PVST, all VLANs run PVRST, or all VLANs run MSTP.
- VTP propagation of the MST configuration is not supported. However, you can manually configure the MST configuration (region name, revision number, and VLAN-to-instance mapping) on each switch within the MST region by using the command-line interface (CLI) or through the SNMP support.
- For load balancing across redundant paths in the network to work, all VLAN-to-instance mapping assignments must match; otherwise, all traffic flows on a single link.

- All MST boundary ports must be forwarding for load balancing between a PVST and an MST cloud or between a PVRST and an MST cloud. For this to occur, the IST master of the MST cloud should also be the root of the CST. If the MST cloud consists of multiple MST regions, one of the MST regions must contain the CST root, and all of the other MST regions must have a better path to the root contained with the MST cloud than a path through the PVST or PVRST cloud. You might have to manually configure the switches in the clouds.
- Partitioning the network into a large number of regions is not recommended. However, if this situation is unavoidable, we recommend that you partition the switched LAN into smaller LANs interconnected by routers or non-Layer 2 devices.

Specifying the MST Region Configuration and Enabling MSTP

For two or more switches to be in the same MST region, they must have the same VLAN-to-instance mapping, the same configuration revision number, and the same name.

A region can have one member or multiple members with the same MST configuration; each member must be capable of processing RSTP BPDUs. There is no limit to the number of MST regions in a network, but each region can support up to 16 spanning-tree instances. You can assign a VLAN to only one spanning-tree instance at a time.

Beginning in privileged EXEC mode, follow these steps to specify the MST region configuration and enable MSTP. This procedure is required.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst configuration**	Enter MST configuration mode.
Step 3	**instance** *instance-id* **vlan** *vlan-range*	Map VLANs to an MST instance. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 1 to 15. • For **vlan** *vlan-range*, the range is 1 to 4094. When you map VLANs to an MST instance, the mapping is incremental, and the range of VLANs specified is added or removed to the existing ones. To specify a VLAN range, use a hyphen; for example, **instance 1 vlan 1-63** maps VLANs 1 through 63 to MST instance 1. To specify a VLAN series, use a comma; for example, **instance 1 vlan 10, 20, 30** maps VLANs 10, 20, and 30 to MST instance 1.
Step 4	**name** *name*	Specify the configuration name. The *name* string has a maximum length of 32 characters and is case sensitive.
Step 5	**revision** *version*	Specify the configuration revision number. The range is 0 to 65535.
Step 6	**show pending**	Verify your configuration by displaying the pending configuration.
Step 7	**exit**	Apply all changes, and return to global configuration mode.

	Command	Purpose
Step 8	**spanning-tree mode mst**	Enable MSTP. RSTP is also enabled. **Caution** Changing spanning-tree modes can disrupt traffic because all spanning-tree instances are stopped for the previous mode and restarted in the new mode. You cannot run both MSTP and PVST or both MSTP and PVRST at the same time.
Step 9	**end**	Return to privileged EXEC mode.
Step 10	**show running-config**	Verify your entries.
Step 11	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default MST region configuration, use the **no spanning-tree mst configuration** global configuration command. To return to the default VLAN-to-instance map, use the **no instance** *instance-id* [**vlan** *vlan-range*] MST configuration command. To return to the default name, use the **no name** MST configuration command. To return to the default revision number, use the **no revision** MST configuration command.To re-enable PVST, use the **no spanning-tree mode** or the **spanning-tree mode pvst** global configuration command.

This example shows how to enter MST configuration mode, map VLANs 10 to 20 to MST instance 1, name the region *region1*, set the configuration revision to 1, display the pending configuration, apply the changes, and return to global configuration mode:

```
Switch(config)# spanning-tree mst configuration
Switch(config-mst)# instance 1 vlan 10-20
Switch(config-mst)# name region1
Switch(config-mst)# revision 1
Switch(config-mst)# show pending
Pending MST configuration
Name      [region1]
Revision  1
Instance  Vlans Mapped
--------  --------------------
0         1-9,21-4094
1         10-20
-------------------------------

Switch(config-mst)# exit
Switch(config)#
```

Configuring the Root Switch

The switch maintains a spanning-tree instance for the group of VLANs mapped to it. A bridge ID, consisting of the switch priority and the switch MAC address, is associated with each instance. The switch with the lowest bridge ID becomes the root switch for the group of VLANs.

To configure a switch to become the root, use the **spanning-tree mst** *instance-id* **root** global configuration command to modify the switch priority from the default value (32768) to a significantly lower value so that the switch becomes the root switch for the specified spanning-tree instance. When you enter this command, the switch checks the switch priorities of the root switches. Because of the extended system ID support, the switch sets its own priority for the specified instance to 24576 if this value will cause this switch to become the root for the specified spanning-tree instance.

If any root switch for the specified instance has a switch priority lower than 24576, the switch sets its own priority to 4096 less than the lowest switch priority. (4096 is the value of the least-significant bit of a 4-bit switch priority value as shown in Table 12-1 on page 12-4.)

Note Catalyst 2950 switches running software earlier than Release 12.1(9)EA1 do not support the extended system ID. Catalyst 2950 switches running software earlier than Release 12.1(9)EA1 do not support the MSTP.

Note If your network consists of switches that both do and do not support the extended system ID, it is unlikely that the switch with the extended system ID support will become the root switch. The extended system ID increases the switch priority value every time the VLAN number is greater than the priority of the connected switches running older software.

Note The root switch for each spanning-tree instance should be a backbone or distribution switch. Do not configure an access switch as the spanning-tree primary root.

Use the **diameter** keyword, which is available only for MST instance 0, to specify the Layer 2 network diameter (that is, the maximum number of switch hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

Note We recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time by using the **spanning-tree mst hello-time**, **spanning-tree mst forward-time**, and the **spanning-tree mst max-age** global configuration commands after configuring the switch as the root switch.

Beginning in privileged EXEC mode, follow these steps to configure a switch as the root switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst** *instance-id* **root primary** [**diameter** *net-diameter* [**hello-time** *seconds*]]	Configure a switch as the root switch. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 15. • (Optional) For **diameter** *net-diameter*, specify the maximum number of switches between any two end stations. The range is 2 to 7. This keyword is available only for MST instance 0. • (Optional) For **hello-time** *seconds*, specify the interval in seconds between the generation of configuration messages by the root switch. The range is 1 to 10 seconds; the default is 2 seconds.

	Command	Purpose
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst** *instance-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst** *instance-id* **root** global configuration command.

Configuring a Secondary Root Switch

When you configure a Catalyst 2950 or Catalyst 2955 switch that supports the extended system ID as the secondary root, the spanning-tree switch priority is modified from the default value (32768) to 28672. The switch is then likely to become the root switch for the specified instance if the primary root switch fails. This is assuming that the other network switches use the default switch priority of 32768 and therefore are unlikely to become the root switch. For Catalyst 2950 switches without the extended system ID support (software earlier than Release 12.1(9)EA1), the switch priority is changed to 16384.

You can execute this command on more than one switch to configure multiple backup root switches. Use the same network diameter and hello-time values that you used when you configured the primary root switch with the **spanning-tree mst** *instance-id* **root primary** global configuration command.

Beginning in privileged EXEC mode, follow these steps to configure a switch as the secondary root switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst** *instance-id* **root secondary** [**diameter** *net-diameter* [**hello-time** *seconds*]]	Configure a switch as the secondary root switch. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 15. • (Optional) For **diameter** *net-diameter*, specify the maximum number of switches between any two end stations. The range is 2 to 7. This keyword is available only for MST instance 0. • (Optional) For **hello-time** *seconds*, specify the interval in seconds between the generation of configuration messages by the root switch. The range is 1 to 10 seconds; the default is 2 seconds. Use the same network diameter and hello-time values that you used when configuring the primary root switch. See the "Configuring the Root Switch" section on page 13-14.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst** *instance-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst** *instance-id* **root** global configuration command.

Configuring the Port Priority

If a loop occurs, the MSTP uses the port priority when selecting an interface to put into the forwarding state. You can assign higher priority values (lower numerical values) to interfaces that you want selected first and lower priority values (higher numerical values) that you want selected last. If all interfaces have the same priority value, the MSTP puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

Beginning in privileged EXEC mode, follow these steps to configure the MSTP port priority of an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify an interface to configure. Valid interfaces include physical ports and port channels. Valid port-channel numbers are 1 to 6.
Step 3	**spanning-tree mst** *instance-id* **port-priority** *priority*	Configure the port priority for an MST instance. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 15. • For *priority*, the range is 0 to 240 in increments of 16. The default is 128. The lower the number, the higher the priority. Valid priority values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show spanning-tree mst interface** *interface-id* or **show spanning-tree mst** *instance-id*	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note The **show spanning-tree mst interface** *interface-id* privileged EXEC command displays information only if the port is in a link-up operative state. Otherwise, you can use the **show running-config interface** privileged EXEC command to confirm the configuration.

To return the interface to its default setting, use the **no spanning-tree mst** *instance-id* **port-priority** interface configuration command.

Configuring the Path Cost

The MSTP path cost default value is derived from the media speed of an interface. If a loop occurs, the MSTP uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all interfaces have the same cost value, the MSTP puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

Beginning in privileged EXEC mode, follow these steps to configure the MSTP cost of an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify an interface to configure. Valid interfaces include physical ports and port channels. Valid port-channel numbers are 1 to 6.
Step 3	**spanning-tree mst** *instance-id* **cost** *cost*	Configure the cost for an MST instance. If a loop occurs, the MSTP uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 15. • For *cost*, the range is 1 to 200000000; the default value is derived from the media speed of the interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show spanning-tree mst interface** *interface-id* or **show spanning-tree mst** *instance-id*	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note The **show spanning-tree mst interface** *interface-id* privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

To return the interface to its default setting, use the **no spanning-tree mst** *instance-id* **cost** interface configuration command.

Configuring the Switch Priority

You can configure the switch priority and make it more likely that the switch will be chosen as the root switch.

Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree mst** *instance-id* **root primary** and the **spanning-tree mst** *instance-id* **root secondary** global configuration commands to modify the switch priority.

Beginning in privileged EXEC mode, follow these steps to configure the switch priority:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst** *instance-id* **priority** *priority*	Configure the switch priority for an MST instance. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 15. • For *priority*, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the switch will be chosen as the root switch. Valid priority values are 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. All other values are rejected.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst** *instance-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst** *instance-id* **priority** global configuration command.

Configuring the Hello Time

You can configure the interval between the generation of configuration messages by the root switch by changing the hello time.

Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree mst** *instance-id* **root primary** and the **spanning-tree mst** *instance-id* **root secondary** global configuration commands to modify the hello time.

Beginning in privileged EXEC mode, follow these steps to configure the hello time for all MST instances:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst hello-time** *seconds*	Configure the hello time for all MST instances. The hello time is the interval between the generation of configuration messages by the root switch. These messages mean that the switch is alive. For *seconds*, the range is 1 to 10; the default is 2.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst hello-time** global configuration command.

Configuring the Forwarding-Delay Time

Beginning in privileged EXEC mode, follow these steps to configure the forwarding-delay time for all MST instances:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst forward-time** *seconds*	Configure the forward time for all MST instances. The forward delay is the number of seconds a port waits before changing from its spanning-tree learning and listening states to the forwarding state. For *seconds*, the range is 4 to 30; the default is 15.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst forward-time** global configuration command.

Configuring the Maximum-Aging Time

Beginning in privileged EXEC mode, follow these steps to configure the maximum-aging time for all MST instances:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst max-age** *seconds*	Configure the maximum-aging time for all MST instances. The maximum-aging time is the number of seconds a switch waits without receiving spanning-tree configuration messages before attempting a reconfiguration. For *seconds*, the range is 6 to 40; the default is 20.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst max-age** global configuration command.

Configuring the Maximum-Hop Count

Beginning in privileged EXEC mode, follow these steps to configure the maximum-hop count for all MST instances:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree mst max-hops** *hop-count*	Specify the number of hops in a region before the BPDU is discarded, and the information held for a port is aged. For *hop-count*, the range is 1 to 40; the default is 20.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree mst max-hops** global configuration command.

Specifying the Link Type to Ensure Rapid Transitions

If you connect a port to another port through a point-to-point link and the local port becomes a designated port, the RSTP negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology as described in the "Rapid Convergence" section on page 13-3.

By default, the link type is determined from the duplex mode of the interface: a full-duplex port is considered to have a point-to-point connection; a half-duplex port is considered to have a shared connection. If you have a half-duplex link physically connected point-to-point to a single port on a remote switch running PVRST or MSTP, you can override the default setting of the link type and enable rapid transitions to the forwarding state.

Beginning in privileged EXEC mode, follow these steps to override the default link-type setting:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 1	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to configure. Valid interfaces include physical ports, VLANs, and port channels. Valid VLAN IDs are 1 to 4094; valid port-channel numbers are 1 to 6.
Step 2	**spanning-tree link-type point-to-point**	Specify that the link type of a port is point-to-point.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree mst interface** *interface-id*	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no spanning-tree link-type** interface configuration command.

Restarting the Protocol Migration Process

A switch running MSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy 802.1D switches. If this switch receives a legacy 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only 802.1D BPDUs on that port. An MSTP switch can also detect that a port is at the boundary of a region when it receives a legacy BPDU, an MST BPDU (version 3) associated with a different region, or an RST BPDU (version 2).

However, the switch does not automatically revert to the MSTP mode if it no longer receives 802.1D BPDUs because it cannot determine whether the legacy switch has been removed from the link unless the legacy switch is the designated switch. A switch also might continue to assign a boundary role to a port when the switch to which it is connected has joined the region.

To restart the protocol migration process (force the renegotiation with neighboring switches) on the entire switch, you can use the **clear spanning-tree detected-protocols** privileged EXEC command. Use the **clear spanning-tree detected-protocols interface** *interface-id* privileged EXEC command to restart the protocol migration process on a specific interface.

Displaying the MST Configuration and Status

To display the spanning-tree status, use one or more of the privileged EXEC commands in Table 13-4:

Table 13-4 Commands for Displaying MST Status

Command	Purpose
show spanning-tree mst configuration	Displays the MST region configuration.
show spanning-tree mst *instance-id*	Displays MST information for the specified instance.
show spanning-tree mst interface *interface-id*	Displays MST information for the specified interface. Valid interfaces include physical ports, VLANs, and port channels. The valid VLAN range is 1 to 4094; the valid port-channel range is 1 to 6.

For information about other keywords for the **show spanning-tree** privileged EXEC command, refer to the command reference for this release.

CHAPTER 14

Configuring Optional Spanning-Tree Features

This chapter describes how to configure optional spanning-tree features. You can configure all of these features when your Catalyst 2950 or Catalyst 2955 switch is running the per-VLAN spanning tree (PVST). You can only configure the noted features when your switch is running the per-VLAN rapid spanning tree (PVRST) and the the Multiple Spanning Tree Protocol (MSTP). To use these features with PVRST and MSTP, you must have the enhanced software image (EI) installed on your switch.

For information on configuring the Spanning Tree Protocol (STP), see Chapter 12, "Configuring STP." For information on configuring the Rapid Spanning Tree Protocol (RSTP), the Multiple Spanning Tree Protocol (MSTP), and PVRST, see Chapter 13, "Configuring RSTP and MSTP."

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding Optional Spanning-Tree Features, page 14-1
- Configuring Optional Spanning-Tree Features, page 14-14
- Displaying the Spanning-Tree Status, page 14-21

Understanding Optional Spanning-Tree Features

These sections describe how the optional spanning-tree features work:

- Understanding Port Fast, page 14-2
- Understanding BPDU Guard, page 14-3
- Understanding BPDU Filtering, page 14-3
- Understanding UplinkFast, page 14-4
- Understanding Cross-Stack UplinkFast, page 14-5
- Understanding BackboneFast, page 14-10
- Understanding EtherChannel Guard, page 14-12
- Understanding Root Guard, page 14-12
- Understanding Loop Guard, page 14-13

Understanding Port Fast

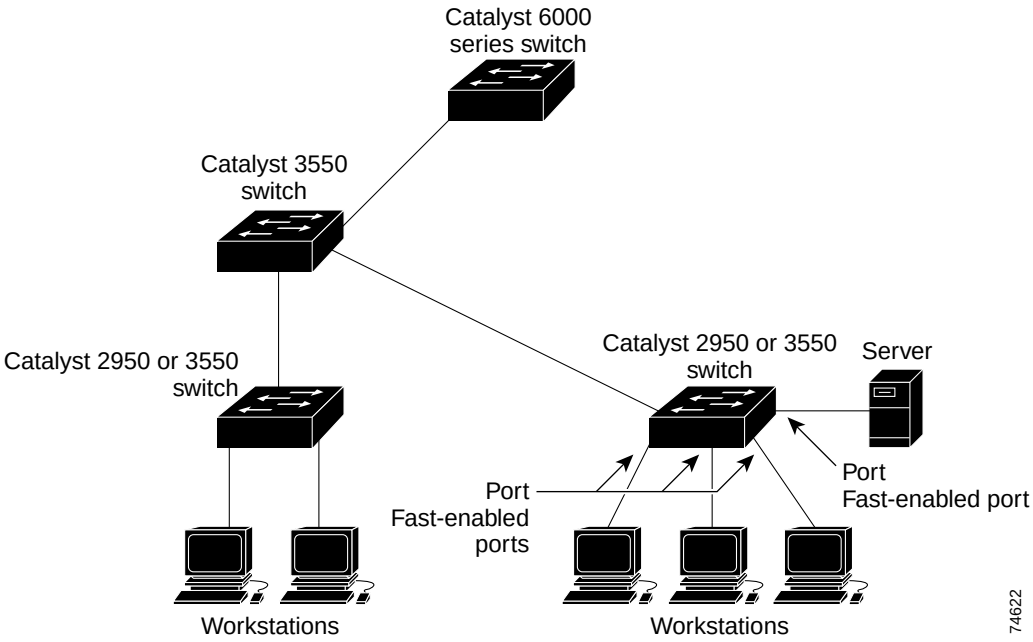
Port Fast immediately brings an interface configured as an access or trunk port to the forwarding state from a blocking state, bypassing the listening and learning states. You can use Port Fast on ports connected to a single workstation or server, as shown in Figure 14-1, to allow those devices to immediately connect to the network, rather than waiting for the spanning tree to converge.

Ports connected to a single workstation or server should not receive bridge protocol data units (BPDUs). A port with Port Fast enabled goes through the normal cycle of spanning-tree status changes when the switch is restarted.

Note Because the purpose of Port Fast is to minimize the time ports must wait for spanning-tree to converge, it is effective only when used on ports connected to end stations. If you enable Port Fast on a port connecting to another switch, you risk creating a spanning-tree loop.

If your switch is running PVST, PVRST, or MSTP, you can enable this feature by using the **spanning-tree portfast** interface configuration or the **spanning-tree portfast default** global configuration command. The PVRST and MSTP are available only if you have the EI installed on your switch.

Figure 14-1 Port Fast-Enabled Ports



Understanding BPDU Guard

The BPDU guard feature can be globally enabled on the switch or can be enabled per interface, but the feature operates with some differences.

At the global level, you can enable BPDU guard on Port Fast-enabled ports by using the **spanning-tree portfast bpduguard default** global configuration command. Spanning tree shuts down ports that are in a Port Fast-operational state. In a valid configuration, Port Fast-enabled ports do not receive BPDUs. Receiving a BPDU on a Port Fast-enabled port signals an invalid configuration, such as the connection of an unauthorized device, and the BPDU guard feature puts the port in the error-disabled state.

At the interface level, you can enable BPDU guard on any port by using the **spanning-tree bpduguard enable** interface configuration command without also enabling the Port Fast feature. When the port receives a BPDU, it is put in the error-disabled state.

The BPDU guard feature provides a secure response to invalid configurations because you must manually put the port back in service. Use the BPDU guard feature in a service-provider network to prevent an access port from participating in the spanning tree.

If your switch is running PVST, PVRST, or MSTP, you can enable the BPDU guard feature for the entire switch or for an interface. The PVRST and MSTP are available only if you have the EI installed on your switch.

Understanding BPDU Filtering

The BPDU filtering feature can be globally enabled on the switch or can be enabled per interface, but the feature operates with some differences.

At the global level, you can enable BPDU filtering on Port Fast-enabled ports by using the **spanning-tree portfast bpdufilter default** global configuration command. This command prevents ports that are in a Port Fast-operational state from sending or receiving BPDUs. The ports still send a few BPDUs at link-up before the switch begins to filter outbound BPDUs. You should globally enable BPDU filtering on a switch so that hosts connected to these ports do not receive BPDUs. If a BPDU is received on a Port Fast-enabled port, the port loses its Port Fast-operational status, and BPDU filtering is disabled.

At the interface level, you can enable BPDU filtering on any port without also enabling the Port Fast feature by using the **spanning-tree bpdufilter enable** interface configuration command. This command prevents the port from sending or receiving BPDUs.

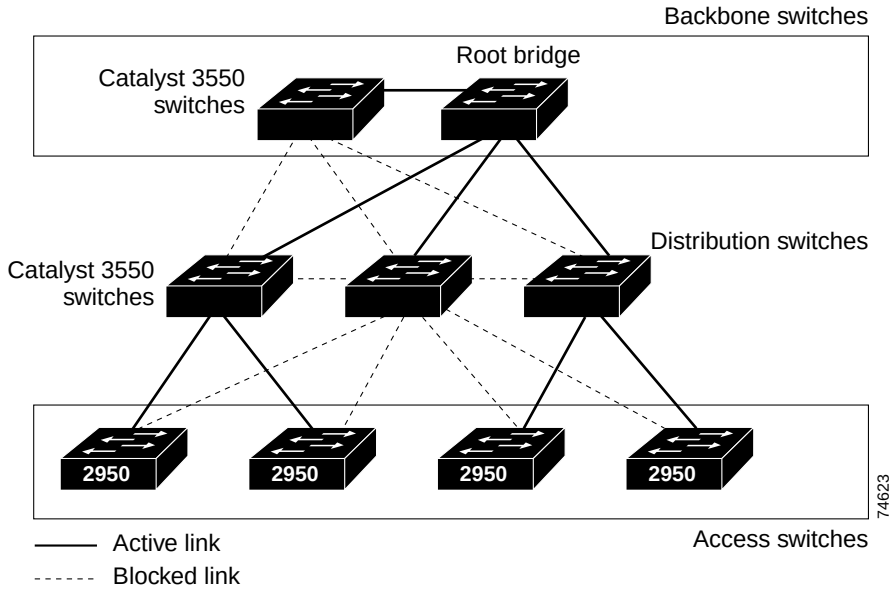
Caution Enabling BPDU filtering on an interface is the same as disabling spanning tree on it and can result in spanning-tree loops.

If your switch is running PVST, PVRST, or MSTP, you can enable the BPDU filtering feature for the entire switch or for an interface. The PVRST and MSTP are available only if you have the EI installed on your switch.

Understanding UplinkFast

Switches in hierarchical networks can be grouped into backbone switches, distribution switches, and access switches. Figure 14-2 shows a complex network where distribution switches and access switches each have at least one redundant link that spanning tree blocks to prevent loops.

Figure 14-2 Switches in a Hierarchical Network



If a switch looses connectivity, it begins using the alternate paths as soon as the spanning tree selects a new root port. By enabling UplinkFast with the **spanning-tree uplinkfast** global configuration command, you can accelerate the choice of a new root port when a link or switch fails or when the spanning tree reconfigures itself. The root port transitions to the forwarding state immediately without going through the listening and learning states, as it would with the normal spanning-tree procedures. The UplinkFast feature is supported only when the switch is running PVST. It is not supported when the switch is running PVRST because PVRST uses fast convergence and takes precedence over UplinkFast.

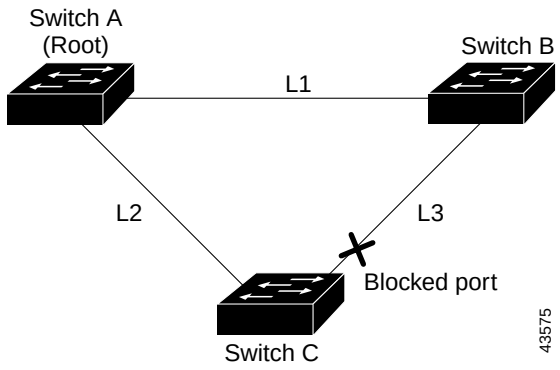
When the spanning tree reconfigures the new root port, other interfaces flood the network with multicast packets, one for each address that was learned on the interface. You can limit these bursts of multicast traffic by reducing the max-update-rate parameter (the default for this parameter is 150 packets per second). However, if you enter zero, station-learning frames are not generated, so the spanning-tree topology converges more slowly after a loss of connectivity.

Note UplinkFast is most useful in wiring-closet switches at the access or edge of the network. It is not appropriate for backbone devices. This feature might not be useful for other types of applications.

UplinkFast provides fast convergence after a direct link failure and achieves load balancing between redundant Layer 2 links using uplink groups. An uplink group is a set of Layer 2 interfaces (per VLAN), only one of which is forwarding at any given time. Specifically, an uplink group consists of the root port (which is forwarding) and a set of blocked ports, except for self-looping ports. The uplink group provides an alternate path in case the currently forwarding link fails.

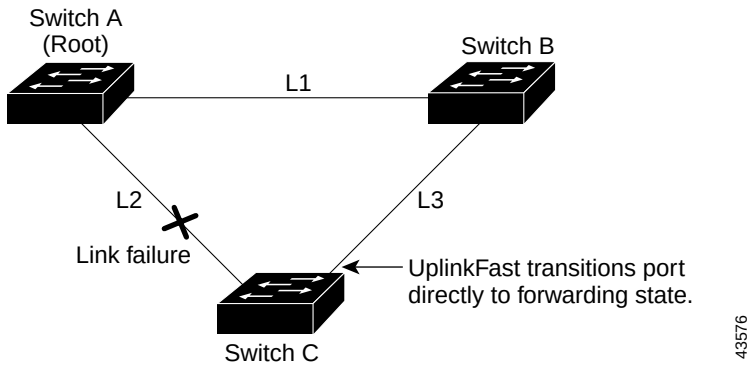
Figure 14-3 shows an example topology with no link failures. Switch A, the root switch, is connected directly to Switch B over link L1 and to Switch C over link L2. The Layer 2 interface on Switch C that is connected directly to Switch B is in a blocking state.

Figure 14-3 UplinkFast Example Before Direct Link Failure



If Switch C detects a link failure on the currently active link L2 on the root port (a *direct* link failure), UplinkFast unblocks the blocked port on Switch C and transitions it to the forwarding state without going through the listening and learning states, as shown in Figure 14-4. This change takes approximately 1 to 5 seconds.

Figure 14-4 UplinkFast Example After Direct Link Failure



Understanding Cross-Stack UplinkFast

Cross-stack UplinkFast (CSUF) provides a fast spanning-tree transition (fast convergence in less than 1 second under normal network conditions) across a stack of switches that use the GigaStack GBICs connected in a shared cascaded configuration (multidrop backbone). During the fast transition, an alternate redundant link on the stack of switches is placed in the forwarding state without causing temporary spanning-tree loops or loss of connectivity to the backbone. With this feature, you can have a redundant and resilient network in some configurations. You enable CSUF by using the **spanning-tree stack-port** interface configuration command. The CSUF feature is supported only when the switch is running PVST. It is not supported when the switch is running PVRST.

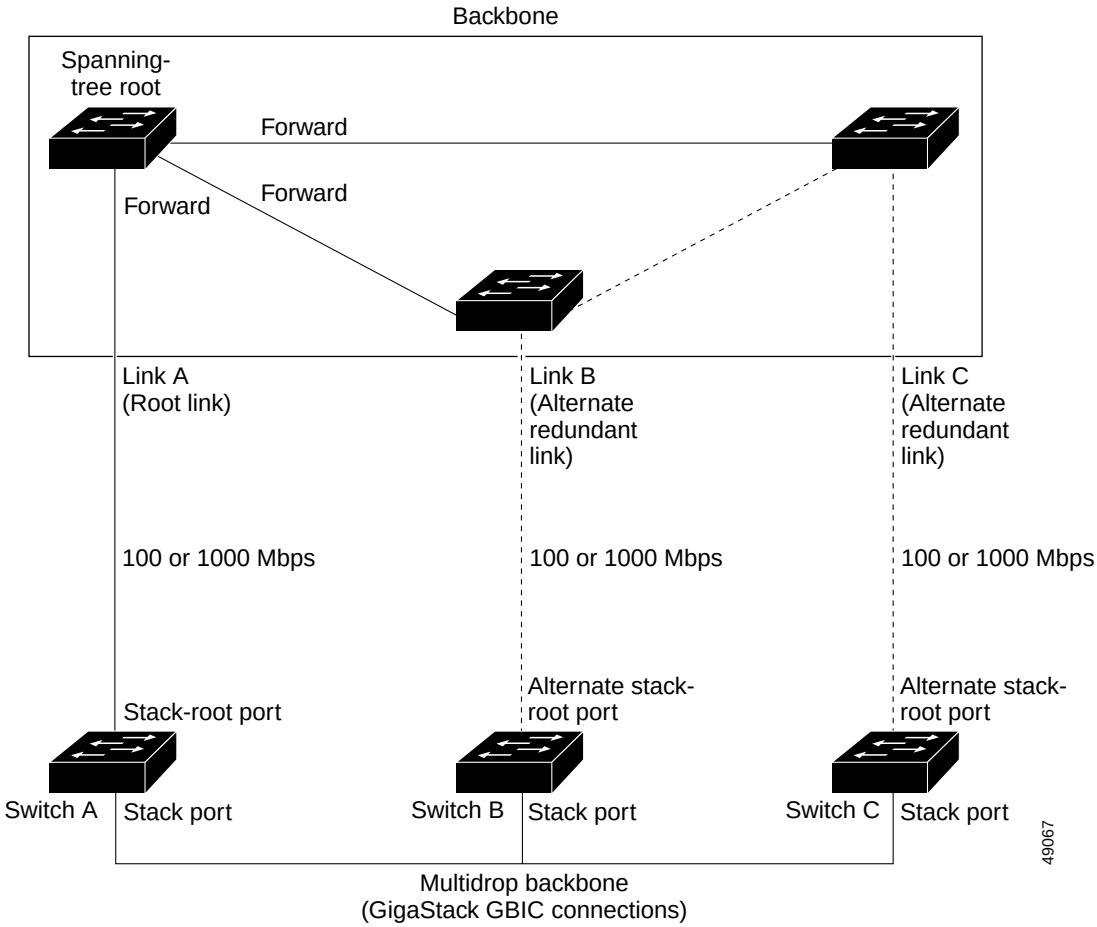
CSUF might not provide a fast transition all the time; in these cases, the normal spanning-tree transition occurs, completing in 30 to 40 seconds. For more information, see the "Events that Cause Fast Convergence" section on page 14-7.

How CSUF Works

CSUF ensures that one link in the stack is elected as the path to the root. As shown in Figure 14-5, Switches A, B, and C are cascaded through the GigaStack GBIC to form a multidrop backbone, which communicates control and data traffic across the switches at the access layer. The switches in the stack use their stack ports to communicate with each other and to connect to the stack backbone; stack ports are always in the spanning-tree forwarding state. The stack-root port on Switch A provides the path to the root of the spanning tree; the alternate stack-root ports on Switches B and C can provide an alternate path to the spanning-tree root if the current stack-root switch fails or if its link to the spanning-tree root fails.

Link A, the root link, is in the spanning-tree forwarding state; Links B and C are alternate redundant links that are in the spanning-tree blocking state. If Switch A fails, if its stack-root port fails, or if Link A fails, CSUF selects either the Switch B or Switch C alternate stack-root port and puts it into the forwarding state in less than 1 second.

Figure 14-5 Cross-Stack UplinkFast Topology



CSUF uses the Stack Membership Discovery Protocol to build a neighbor list of stack members through the receipt of discovery hello packets. When certain link loss or spanning-tree events occur (described in "Events that Cause Fast Convergence" section on page 14-7), the Fast Uplink Transition Protocol uses the neighbor list to send fast-transition requests on the stack port to stack members.

The switch sending the fast-transition request needs to do a fast transition to the forwarding state of a port that it has chosen as the root port, and it must obtain an acknowledgement from each stack switch before performing the fast transition.

Each switch in the stack determines if the sending switch is a better choice than itself to be the stack root of this spanning-tree instance by comparing the root, cost, and bridge ID. If the sending switch is the best choice as the stack root, each switch in the stack returns an acknowledgement; otherwise, it does not respond to the sending switch (drops the packet). The sending switch then has not received acknowledgements from all stack switches.

When acknowledgements are received from all stack switches, the Fast Uplink Transition Protocol on the sending switch immediately transitions its alternate stack-root port to the forwarding state. If acknowledgements from all stack switches are not obtained by the sending switch, the normal spanning-tree transitions (blocking, listening, learning, and forwarding) take place, and the spanning-tree topology converges at its normal rate (2 * forward-delay time + max-age time).

The Fast Uplink Transition Protocol is implemented on a per-VLAN basis and affects only one spanning-tree instance at a time.

Events that Cause Fast Convergence

Depending on the network event or failure, the CSUF fast convergence might or might not occur.

Fast convergence (less than 1 second under normal network conditions) occurs under these circumstances:

- The stack-root port link fails.

  If two switches in the stack have alternate paths to the root, only one of the switches performs the fast transition.
- The failed link, which connects the stack root to the spanning-tree root, recovers.
- A network reconfiguration causes a new stack-root switch to be selected.
- A network reconfiguration causes a new port on the current stack-root switch to be chosen as the stack-root port.

Note The fast transition might not occur if multiple events occur simultaneously. For example, if a stack member switch is powered off, and at the same time, the link connecting the stack root to the spanning-tree root comes back up, the normal spanning-tree convergence occurs.

Normal spanning-tree convergence (30 to 40 seconds) occurs under these conditions:

- The stack-root switch is powered off, or the software failed.
- The stack-root switch, which was powered off or failed, is powered on.
- A new switch, which might become the stack root, is added to the stack.
- A switch other than the stack root is powered off or failed.
- A link fails between stack ports on the multidrop backbone.

Limitations

These limitations apply to CSUF:

- CSUF uses the GigaStack GBIC and runs on all Catalyst 3550 switches, all Catalyst 3500 XL switches, Catalyst 2950 switches with GBIC module slots, and only on modular Catalyst 2900 XL switches that have the 1000BASE-X module installed.
- Up to nine stack switches can be connected through their stack ports to the multidrop backbone. Only one stack port per switch is supported.
- Each stack switch can be connected to the spanning-tree backbone through one uplink.
- If the stack consists of a mixture of Catalyst 3550, Catalyst 3500 XL, Catalyst 2950, and Catalyst 2900 XL switches, up to 64 VLANs with spanning tree enabled are supported. If the stack consists of only Catalyst 3550 switches, up to 128 VLANs with spanning tree enabled are supported.

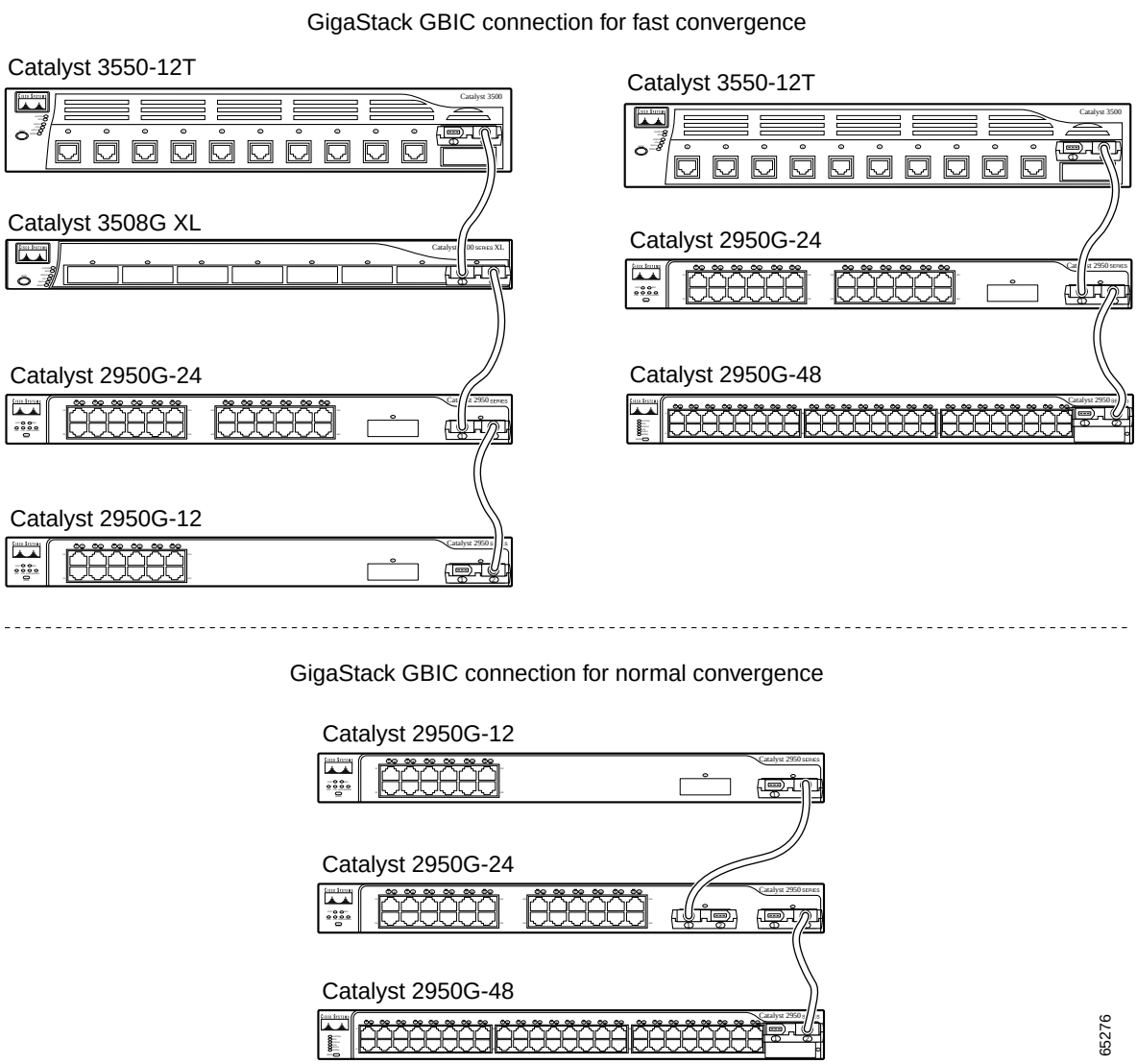
Connecting the Stack Ports

A fast transition occurs across the stack of switches if the multidrop backbone connections are a continuous link from one GigaStack GBIC to another as shown in the top half of Figure 14-6. The bottom half of Figure 14-6 shows how to connect the GigaStack GBIC to achieve a normal convergence time.

You should follow these guidelines:

- A switch supports only one stack port.
- Do not connect alternate stack-root ports to stack ports.
- Connect all stack ports on the switch stack to the multidrop backbone.
- You can connect the open ports on the top and bottom GigaStack GBICs within the same stack to form a redundant link.

Figure 14-6 GigaStack GBIC Connections and Spanning-Tree Convergence



Understanding BackboneFast

BackboneFast detects indirect failures in the core of the backbone. BackboneFast is a complementary technology to the UplinkFast feature, which responds to failures on links directly connected to access switches. BackboneFast optimizes the maximum-age timer, which determines the amount of time the switch stores protocol information received on an interface. When a switch receives an inferior BPDU from the designated port of another switch, the BPDU is a signal that the other switch might have lost its path to the root, and BackboneFast tries to find an alternate path to the root.

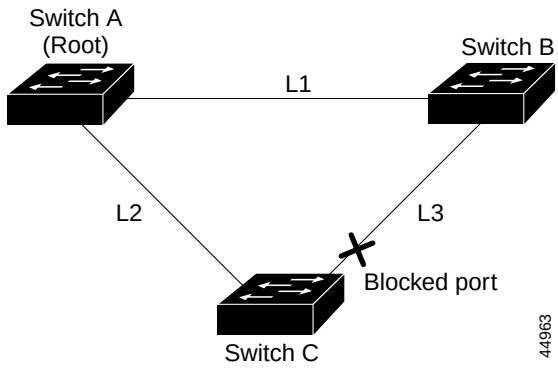
BackboneFast, which is enabled by using the **spanning-tree backbonefast** global configuration command, starts when a root port or blocked port on a switch receives inferior BPDUs from its designated bridge. An inferior BPDU identifies one switch as both the root bridge and the designated bridge. When a switch receives an inferior BPDU, it means that a link to which the switch is not directly connected (an *indirect* link) has failed (that is, the designated bridge has lost its connection to the root switch). Under spanning-tree rules, the switch ignores inferior BPDUs for the configured maximum aging time specified by the **spanning-tree max-age** global configuration command. The BackboneFast feature is supported only when the switch is running PVST. It is not supported when the switch is running PVRST.

The switch tries to determine if it has an alternate path to the root switch. If the inferior BPDU arrives on a blocked port, the root port and other blocked ports on the switch become alternate paths to the root switch. (Self-looped ports are not considered alternate paths to the root switch.) If the inferior BPDU arrives on the root port, all blocked ports become alternate paths to the root switch. If the inferior BPDU arrives on the root port and there are no blocked ports, the switch assumes that it has lost connectivity to the root switch, causes the maximum aging time on the root port to expire, and becomes the root switch according to normal spanning-tree rules.

If the switch has alternate paths to the root switch, it uses these alternate paths to send a root link query (RLQ) request. The switch sends the RLQ request on all alternate paths to the root switch and waits for an RLQ reply from other switches in the network. If the switch determines that it still has an alternate path to the root, it expires the maximum aging time on the port that received the inferior BPDU. If all the alternate paths to the root switch indicate that the switch has lost connectivity to the root switch, the switch expires the maximum aging time on the port that received the RLQ reply. If one or more alternate paths can still connect to the root switch, the switch makes all ports on which it received an inferior BPDU its designated ports and moves them from the blocking state (if they were in the blocking state), through the listening and learning states, and into the forwarding state.

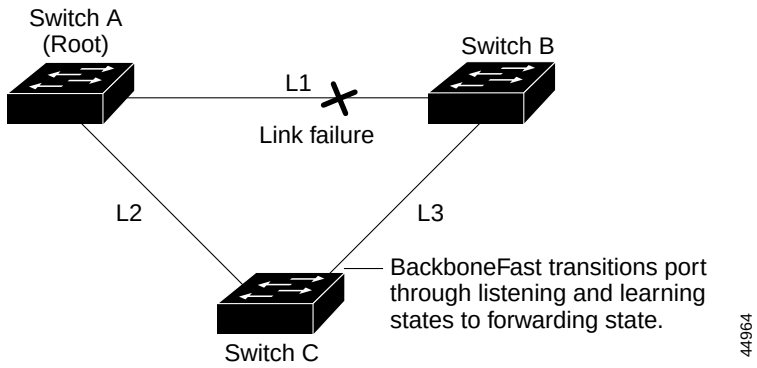
Figure 14-7 shows an example topology with no link failures. Switch A, the root switch, connects directly to Switch B over link L1 and to Switch C over link L2. The Layer 2 interface on Switch C that connects directly to Switch B is in the blocking state.

Figure 14-7 BackboneFast Example Before Indirect Link Failure



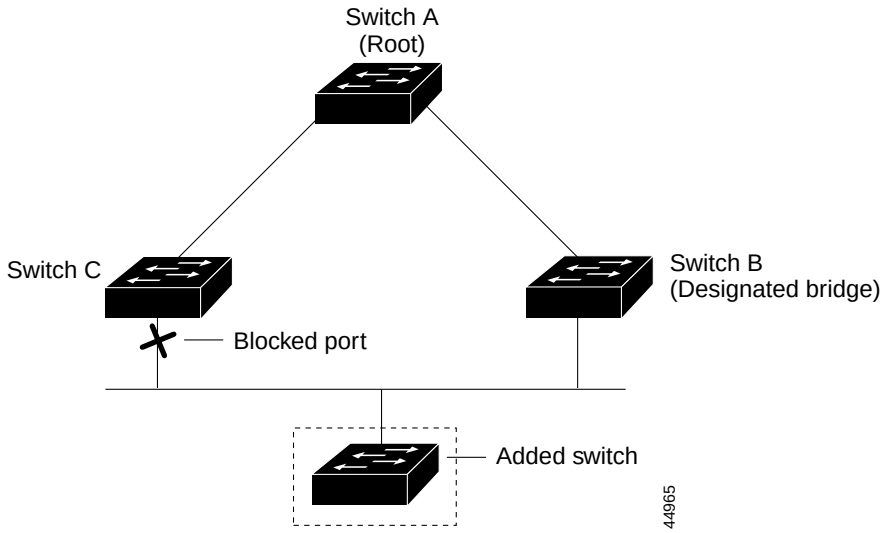
If link L1 fails as shown in Figure 14-8, Switch C cannot detect this failure because it is not connected directly to link L1. However, because Switch B is directly connected to the root switch over L1, it detects the failure, elects itself the root, and begins sending BPDUs to Switch C, identifying itself as the root. When Switch C receives the inferior BPDUs from Switch B, Switch C assumes that an indirect failure has occurred. At that point, BackboneFast allows the blocked port on Switch C to move immediately to the listening state without waiting for the maximum aging time for the port to expire. BackboneFast then transitions the Layer 2 interface on Switch C to the forwarding state, providing a path from Switch B to Switch A. This switchover takes approximately 30 seconds, twice the Forward Delay time if the default Forward Delay time of 15 seconds is set. Figure 14-8 shows how BackboneFast reconfigures the topology to account for the failure of link L1.

Figure 14-8 BackboneFast Example After Indirect Link Failure



If a new switch is introduced into a shared-medium topology as shown in Figure 14-9, BackboneFast is not activated because the inferior BPDUs did not come from the recognized designated bridge (Switch B). The new switch begins sending inferior BPDUs that indicate it is the root switch. However, the other switches ignore these inferior BPDUs, and the new switch learns that Switch B is the designated bridge to Switch A, the root switch.

Figure 14-9 Adding a Switch in a Shared-Medium Topology



Understanding EtherChannel Guard

You can use EtherChannel guard to detect an EtherChannel misconfiguration between the switch and a connected device. A misconfiguration can occur if the switch interfaces are configured in an EtherChannel, but the interfaces on the other device are not. A misconfiguration can also occur if the channel parameters are not the same at both ends of the EtherChannel. For EtherChannel configuration guidelines, see the "EtherChannel Configuration Guidelines" section on page 28-8.

If the switch detects a misconfiguration on the other device, EtherChannel guard places the switch interfaces in the error-disabled state, and this error message appears:

```
PM-4-ERR_DISABLE: Channel-misconfig error detected on [chars], putting [chars] in
err-disable state.
```

If your switch is running PVST, PVRST, or MSTP, you can enable this feature by using the **spanning-tree etherchannel guard misconfig** global configuration command. The PVRST and MSTP are available only if you have the EI installed on your switch.

Understanding Root Guard

The Layer 2 network of a service provider (SP) can include many connections to switches that are not owned by the SP. In such a topology, the spanning tree can reconfigure itself and select a *customer switch* as the root switch, as shown in Figure 14-10. You can avoid this situation by configuring root guard on SP switch interfaces that connect to switches in your customer's network. If spanning-tree calculations cause an interface in the customer network to be selected as the root port, root guard then places the interface in the root-inconsistent (blocked) state to prevent the customer's switch from becoming the root switch or being in the path to the root.

If a switch outside the SP network becomes the root switch, the interface is blocked (root-inconsistent state), and spanning tree selects a new root switch. The customer's switch does not become the root switch and is not in the path to the root.

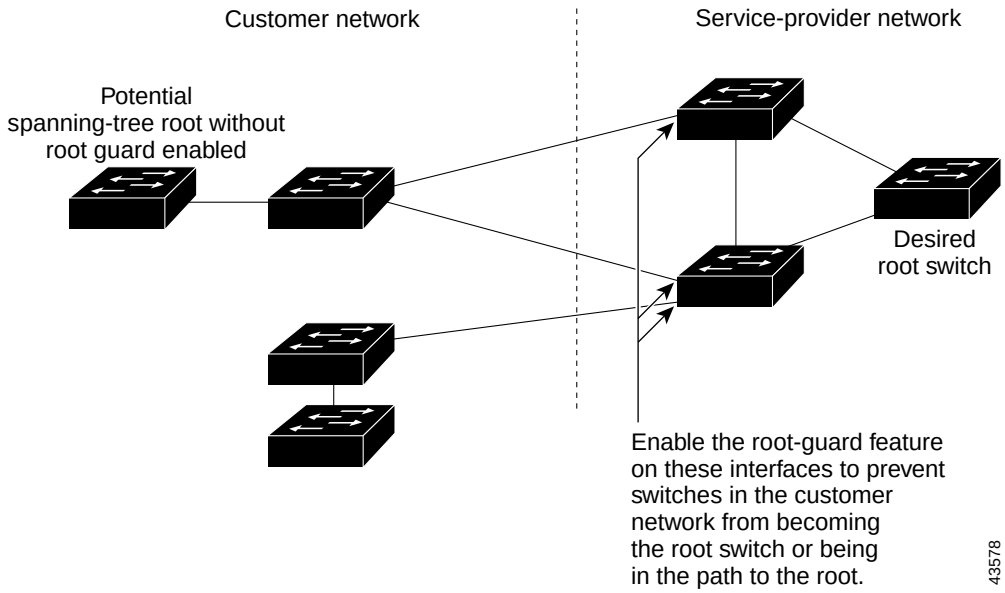
If the switch is operating in multiple spanning-tree (MST) mode, root guard forces the port to be a designated port. If a boundary port is blocked in an internal spanning-tree (IST) instance because of root guard, the port also is blocked in all MST instances. A boundary port is a port that connects to a LAN, the designated switch of which is either an 802.1D switch or a switch with a different MST region configuration.

Root guard enabled on an interface applies to all the VLANs to which the interface belongs. VLANs can be grouped and mapped to an MST instance.

If your switch is running PVST, PVRST, or MSTP, you can enable this feature by using the **spanning-tree guard root** interface configuration command. The PVRST and MSTP are available only if you have the EI installed on your switch.

Caution Misuse of the root-guard feature can cause a loss of connectivity.

Figure 14-10 Root Guard in a Service-Provider Network



Understanding Loop Guard

You can use loop guard to prevent alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link. This feature is most effective when it is configured on the entire switched network.

If your switch is running PVST, PVRST, or MSTP, you can enable this feature by using the **spanning-tree loopguard default** global configuration command. The PVRST and MSTP are available only if you have the EI installed on your switch.

When the switch is operating in PVST mode, loop guard prevents alternate and root ports from becoming designated ports, and spanning tree does not send BPDUs on root or alternate ports.

When the switch is operating in MST mode, BPDUs are not sent on nonboundary ports only if the port is blocked by loop guard in all MST instances. On a boundary port, loop guard blocks the port in all MST instances.

Configuring Optional Spanning-Tree Features

These sections describe how to configure optional spanning-tree features:

- Default Optional Spanning-Tree Configuration, page 14-14
- Enabling Port Fast, page 14-14
- Enabling BPDU Guard, page 14-15
- Enabling BPDU Filtering, page 14-16
- Enabling UplinkFast for Use with Redundant Links, page 14-17
- Enabling Cross-Stack UplinkFast, page 14-18
- Enabling BackboneFast, page 14-19
- Enabling EtherChannel Guard, page 14-19
- Enabling Root Guard, page 14-20
- Enabling Loop Guard, page 14-20

Default Optional Spanning-Tree Configuration

Table 14-1 shows the default optional spanning-tree configuration.

Table 14-1 Default Optional Spanning-Tree Configuration

Feature	Default Setting
Port Fast, BPDU filtering, BPDU guard	Globally disabled (unless they are individually configured per interface).
UplinkFast	Globally disabled.
CSUF	Disabled on all interfaces.
BackboneFast	Globally disabled.
EtherChannel guard	Globally enabled.
Root guard	Disabled on all interfaces.
Loop guard	Disabled on all interfaces.

Enabling Port Fast

A port with the Port Fast feature enabled is moved directly to the spanning-tree forwarding state without waiting for the standard forward-time delay.

Caution Use Port Fast *only* when connecting a single end station to an access or trunk port. Enabling this feature on a port connected to a switch or hub could prevent spanning tree from detecting and disabling loops in your network, which could cause broadcast storms and address-learning problems.

If you enable the voice VLAN feature, the Port Fast feature is automatically enabled. When you disable voice VLAN, the Port Fast feature is not automatically disabled. For more information, see Chapter 17, "Configuring Voice VLAN."

You can enable this feature if your switch is running PVST, PVRST, or MSTP. The PVRST and MSTP are available only if you have the EI installed on your switch.

Beginning in privileged EXEC mode, follow these steps to enable Port Fast:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify an interface to configure.
Step 3	**spanning-tree portfast** [**trunk**]	Enable Port Fast on an access port connected to a single workstation or server. By specifying the **trunk** keyword, you can enable Port Fast on a trunk port. **Caution** Make sure that there are no loops in the network between the trunk port and the workstation or server before you enable Port Fast on a trunk port. By default, Port Fast is disabled on all ports.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show spanning-tree interface** *interface-id* **portfast**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note You can use the **spanning-tree portfast default** global configuration command to globally enable the Port Fast feature on all nontrunking ports.

To disable the Port Fast feature, use the **spanning-tree portfast disable** interface configuration command.

Enabling BPDU Guard

When you globally enable BPDU guard on ports that are Port Fast-enabled (the ports are in a Port Fast-operational state), spanning tree shuts down Port Fast-enabled ports that receive BPDUs.

In a valid configuration, Port Fast-enabled ports do not receive BPDUs. Receiving a BPDU on a Port Fast-enabled port signals an invalid configuration, such as the connection of an unauthorized device, and the BPDU guard feature puts the port in the error-disabled state. The BPDU guard feature provides a secure response to invalid configurations because you must manually put the port back in service. Use the BPDU guard feature in a service-provider network to prevent an access port from participating in the spanning tree.

Caution Configure Port Fast only on ports that connect to end stations; otherwise, an accidental topology loop could cause a data packet loop and disrupt switch and network operation.

You can also use the **spanning-tree bpduguard enable** interface configuration command to enable BPDU guard on any port without also enabling the Port Fast feature. When the port receives a BPDU, it is put in the error-disabled state.

You can enable the BPDU guard feature if your switch is running PVST, PVRST, or MSTP. The PVRST and MSTP are available only if you have the EI installed on your switch.

Beginning in privileged EXEC mode, follow these steps to globally enable the BPDU guard feature:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree portfast bpduguard default**	Globally enable BPDU guard. By default, BPDU guard is disabled.
Step 3	**interface** *interface-id*	Enter interface configuration mode, and specify the interface connected to an end station.
Step 4	**spanning-tree portfast**	Enable the Port Fast feature.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable BPDU guard, use the **no spanning-tree portfast bpduguard default** global configuration command.

You can override the setting of the **no spanning-tree portfast bpduguard default** global configuration command by using the **spanning-tree bpduguard enable** interface configuration command.

Enabling BPDU Filtering

When you globally enable BPDU filtering on Port Fast-enabled ports, it prevents ports that are in a Port Fast-operational state from sending or receiving BPDUs. The ports still send a few BPDUs at link-up before the switch begins to filter outbound BPDUs. You should globally enable BPDU filtering on a switch so that hosts connected to these ports do not receive BPDUs. If a BPDU is received on a Port Fast-enabled port, the port loses its Port Fast-operational status, and BPDU filtering is disabled.

Caution Configure Port Fast only on ports that connect to end stations; otherwise, an accidental topology loop could cause a data packet loop and disrupt switch and network operation.

You can also use the **spanning-tree bpdufilter enable** interface configuration command to enable BPDU filtering on any port without also enabling the Port Fast feature. This command prevents the port from sending or receiving BPDUs.

Caution Enabling BPDU filtering on an interface is the same as disabling spanning tree on it and can result in spanning-tree loops.

You can enable the BPDU filtering feature if your switch is running PVST, PVRST, or MSTP. The PVRST and MSTP are available only if you have the EI installed on your switch.

Beginning in privileged EXEC mode, follow these steps to globally enable the BPDU filtering feature:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree portfast bpdufilter default**	Globally enable BPDU filtering. By default, BPDU filtering is disabled.
Step 3	**interface** *interface-id*	Enter interface configuration mode, and specify the interface connected to an end station.
Step 4	**spanning-tree portfast**	Enable the Port Fast feature.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable BPDU filtering, use the **no spanning-tree portfast bpdufilter default** global configuration command.

You can override the setting of the **no spanning-tree portfast bpdufilter default** global configuration command by using the **spanning-tree bpdufilter enable** interface configuration command.

Enabling UplinkFast for Use with Redundant Links

UplinkFast cannot be enabled on VLANs that have been configured for switch priority. To enable UplinkFast on a VLAN with switch priority configured, first restore the switch priority on the VLAN to the default value by using the **no spanning-tree vlan** *vlan-id* **priority** global configuration command.

Note When you enable UplinkFast, it affects all VLANs on the switch. You cannot configure UplinkFast on an individual VLAN.

The UplinkFast feature is supported only when the switch is running PVST. It is not supported when the switch is running PVRST.

Beginning in privileged EXEC mode, follow these steps to enable UplinkFast:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree uplinkfast** [**max-update-rate** *pkts-per-second*]	Enable UplinkFast. (Optional) For *pkts-per-second*, the range is 0 to 32000 packets per second; the default is 150. If you set the rate to 0, station-learning frames are not generated, and the spanning-tree topology converges more slowly after a loss of connectivity.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree summary**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

When UplinkFast is enabled, the switch priority of all VLANs is set to 49152. If you change the path cost to a value less than 3000 and you enable UplinkFast or UplinkFast is already enabled, the path cost of all interfaces and VLAN trunks is increased by 3000 (if you change the path cost to 3000 or above, the path cost is not altered). The changes to the switch priority and the path cost reduces the chance that the switch will become the root switch.

When UplinkFast is disabled, the switch priorities of all VLANs and path costs of all interfaces are set to default values if you did not modify them from their defaults.

To return the update packet rate to the default setting, use the **no spanning-tree uplinkfast max-update-rate** global configuration command. To disable UplinkFast, use the **no spanning-tree uplinkfast** command.

Enabling Cross-Stack UplinkFast

Before enabling CSUF, make sure your stack switches are properly connected. For more information, see the "Connecting the Stack Ports" section on page 14-8.

The CSUF feature is supported only when the switch is running PVST. It is not supported when the switch is running PVRST.

Beginning in privileged EXEC mode, follow these steps to enable CSUF:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree uplinkfast** [**max-update-rate** *pkts-per-second*]	Enable UplinkFast on the switch. (Optional) For **max-update-rate** *pkts-per-second*, specify the number of packets per second at which update packets are sent. The range is 0 to 65535; the default is 150 packets per second.
Step 1	**interface** *interface-id*	Enter interface configuration mode, and specify the GBIC interface on which to enable CSUF.
Step 2	**spanning-tree stack-port**	Enable CSUF on only one stack-port GBIC interface. The stack port connects to the GigaStack GBIC multidrop backbone. If you try to enable CSUF on a Fast Ethernet or a Gigabit-capable Ethernet port, you receive an error message. If CSUF is already enabled on an interface and you try to enable it on another interface, you receive an error message. You must disable CSUF on the first interface before enabling it on a new interface. Use this command only on access switches.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable CSUF on an interface, use the **no spanning-tree stack-port** interface configuration command. To disable UplinkFast on the switch and all its VLANs, use the **no spanning-tree uplinkfast** global configuration command.

Enabling BackboneFast

You can enable BackboneFast to detect indirect link failures and to start the spanning-tree reconfiguration sooner.

Note If you use BackboneFast, you must enable it on all switches in the network. BackboneFast is not supported on Token Ring VLANs. This feature is supported for use with third-party switches.

The BackboneFast feature is supported only when the switch is running PVST. It is not supported when the switch is running PVRST.

Beginning in privileged EXEC mode, follow these steps to enable BackboneFast:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree backbonefast**	Enable BackboneFast.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree summary**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable the BackboneFast feature, use the **no spanning-tree backbonefast** global configuration command.

Enabling EtherChannel Guard

You can enable EtherChannel guard to detect an EtherChannel misconfiguration that causes a loop.

You can enable this feature if your switch is running PVST, PVRST, or MSTP. The PVRST and MSTP are available only if you have the EI installed on your switch.

Beginning in privileged EXEC mode, follow these steps to enable EtherChannel guard:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**spanning-tree etherchannel guard misconfig**	Enable EtherChannel guard.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show spanning-tree summary**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable the EtherChannel guard feature, use the **no spanning-tree etherchannel guard misconfig** global configuration command.

You can use the **show interfaces status err-disabled** privileged EXEC command to determine which switch ports are disabled because of an EtherChannel misconfiguration. On the remote device, you can enter the **show etherchannel summary** privileged EXEC command to verify the EtherChannel configuration.

After the configuration is corrected, enter the **shutdown** and **no shutdown** commands on the port-channel interfaces that were misconfigured.

Enabling Root Guard

Root guard enabled on an interface applies to all the VLANs to which the interface belongs.

Do not enable the root guard on interfaces to be used by the UplinkFast feature. With UplinkFast, the backup interfaces (in the blocked state) replace the root port in the case of a failure. However, if root guard is also enabled, all the backup interfaces used by the UplinkFast feature are placed in the root-inconsistent state (blocked) and are prevented from reaching the forwarding state.

Note You cannot enable both root guard and loop guard at the same time.

You can enable this feature if your switch is running PVST, PVRST, or MSTP. The PVRST and MSTP are available only if you have the EI installed on your switch.

Beginning in privileged EXEC mode, follow these steps to enable root guard on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify an interface to configure.
Step 3	**spanning-tree guard root**	Enable root guard on the interface. By default, root guard is disabled on all interfaces.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable root guard, use the **no spanning-tree guard** interface configuration command.

Enabling Loop Guard

You can use loop guard to prevent alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link. This feature is most effective when it is configured on the entire switched network. Loop guard operates only on ports that are considered point-to-point by the spanning tree.

Note You cannot enable both loop guard and root guard at the same time.

You can enable this feature if your switch is running PVST, PVRST, or MSTP. The PVRST and MSTP are available only if you have the EI installed on your switch.

Beginning in privileged EXEC mode, follow these steps to enable loop guard:

	Command	Purpose
Step 1	**show spanning-tree active** or **show spanning-tree mst**	Determine which ports are alternate or root ports.
Step 2	**configure terminal**	Enter global configuration mode.
Step 3	**spanning-tree loopguard default**	Enable loop guard. By default, loop guard is disabled.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To globally disable loop guard, use the **no spanning-tree loopguard default** global configuration command. You can override the setting of the **no spanning-tree loopguard default** global configuration command by using the **spanning-tree guard loop** interface configuration command.

Displaying the Spanning-Tree Status

To display the spanning-tree status, use one or more of the privileged EXEC commands in Table 14-2:

Table 14-2 Commands for Displaying the Spanning-Tree Status

Command	Purpose
show spanning-tree active	Displays spanning-tree information on active interfaces only.
show spanning-tree detail	Displays a detailed summary of interface information.
show spanning-tree interface *interface-id*	Displays spanning-tree information for the specified interface.
show spanning-tree mst interface *interface-id*	Displays MST information for the specified interface.
show spanning-tree summary [**totals**]	Displays a summary of port states or displays the total lines of the spanning-tree state section.

For information about other keywords for the **show spanning-tree** privileged EXEC command, refer to the command reference for this release.

CHAPTER 15

Configuring VLANs

This chapter describes how to configure normal-range VLANs (VLAN IDs 1 to 1005) and extended-range VLANs (VLAN IDs 1006 to 4094) on your Catalyst 2950 or Catalyst 2955 switch. It includes information about VLAN modes and the VLAN Membership Policy Server (VMPS).

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

The chapter includes these sections:

- Understanding VLANs, page 15-1
- Configuring Normal-Range VLANs, page 15-4
- Configuring Extended-Range VLANs, page 15-12
- Displaying VLANs, page 15-14
- Configuring VLAN Trunks, page 15-15
- Configuring VMPS, page 15-25

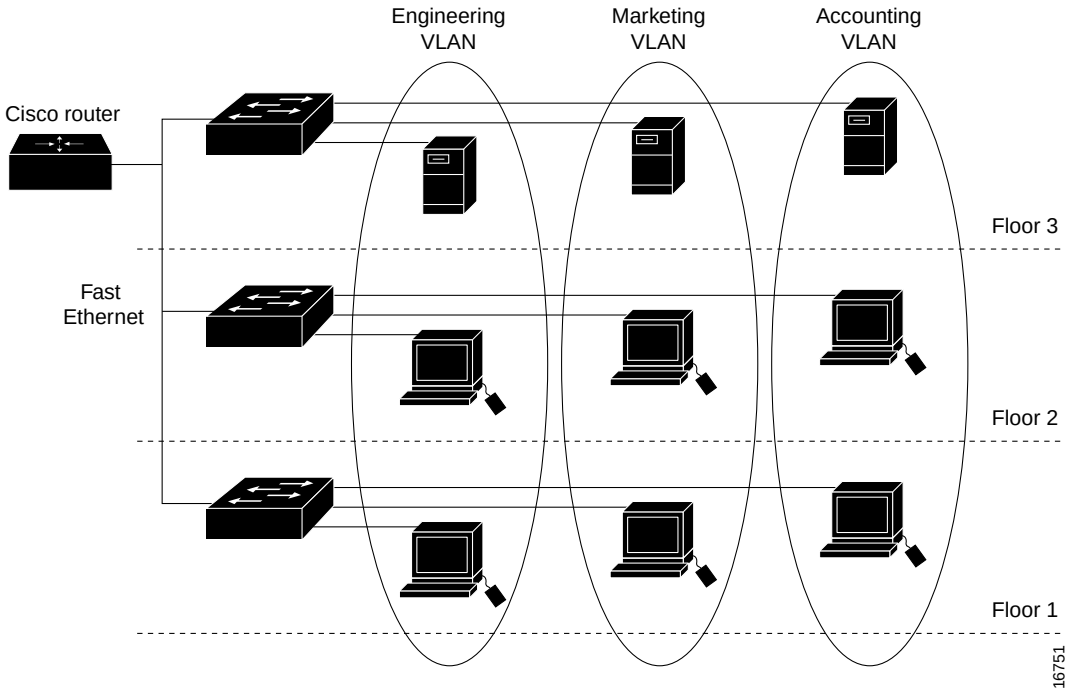
Understanding VLANs

A VLAN is a switched network that is logically segmented by function, project team, or application, without regard to the physical locations of the users. VLANs have the same attributes as physical LANs, but you can group end stations even if they are not physically located on the same LAN segment. Any switch port can belong to a VLAN, and unicast, broadcast, and multicast packets are forwarded and flooded only to end stations in the VLAN. Each VLAN is considered a logical network, and packets destined for stations that do not belong to the VLAN must be forwarded through a router or bridge as shown in Figure 15-1. Because a VLAN is considered a separate logical network, it contains its own bridge Management Information Base (MIB) information and can support its own implementation of spanning tree. See Chapter 12, “Configuring STP” and Chapter 13, “Configuring RSTP and MSTP.”

Note Before you create VLANs, you must decide whether to use VLAN Trunking Protocol (VTP) to maintain global VLAN configuration for your network. For more information on VTP, see Chapter 16, “Configuring VTP.”

Figure 15-1 shows an example of VLANs segmented into logically defined networks.

Figure 15-1 VLANs as Logically Defined Networks



VLANs are often associated with IP subnetworks. For example, all the end stations in a particular IP subnet belong to the same VLAN. Interface VLAN membership on the switch is assigned manually on an interface-by-interface basis. When you assign switch interfaces to VLANs by using this method, it is known as interface-based, or static, VLAN membership.

Supported VLANs

Catalyst 2950 switches that run the standard software image (SI) support 64 VLANs; Catalyst 2950 and Catalyst 2955 switches that run the enhanced software image (EI) support 250 VLANs. Refer to the release notes for the list of switches that support each image. VLANs are identified with a number from 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. VLAN IDs 1002 through 1005 are reserved for Token Ring and FDDI VLANs. VTP only learns normal-range VLANs, with VLAN IDs 1 to 1005; VLAN IDs greater than 1005 are extended-range VLANs and are not stored in the VLAN database. The switch must be in VTP transparent mode when you create VLAN IDs from 1006 to 4094.

The switch supports per-VLAN spanning tree (PVST) and per-VLAN rapid spanning tree (PVRST) with a maximum of 64 spanning-tree instances. One spanning-tree instance is allowed per VLAN. See the "Normal-Range VLAN Configuration Guidelines" section on page 15-5 for more information about the number of spanning-tree instances and the number of VLANs. The switch supports IEEE 802.1Q trunking for sending VLAN traffic over Ethernet ports.

VLAN Port Membership Modes

You configure a port to belong to a VLAN by assigning a membership mode that determines the kind of traffic the port carries and the number of VLANs to which it can belong. Table 15-1 lists the membership modes and membership and VTP characteristics.

Table 15-1 Port Membership Modes

Membership Mode	VLAN Membership Characteristics	VTP Characteristics
Static-access	A static-access port can belong to one VLAN and is manually assigned to that VLAN. For more information, see the "Assigning Static-Access Ports to a VLAN" section on page 15-11.	VTP is not required. If you do not want VTP to globally propagate information, set the VTP mode to transparent to disable VTP. To participate in VTP, there must be at least one trunk port on the switch connected to a trunk port of a second switch.
802.1Q trunk	A trunk port is a member of all VLANs by default, including extended-range VLANs, but membership can be limited by configuring the allowed-VLAN list. You can also modify the pruning-eligible list to block flooded traffic to VLANs on trunk ports that are included in the list. For information about configuring trunk ports, see the "Configuring an Ethernet Interface as a Trunk Port" section on page 15-17.	VTP is recommended but not required. VTP maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP exchanges VLAN configuration messages with other switches over trunk links.
Dynamic access	A dynamic-access port can belong to one normal-range VLAN (VLAN ID 1 to 1005) and is dynamically assigned by a VMPS. The VMPS can be a Catalyst 5000 or Catalyst 6000 series switch, for example, but never a Catalyst 2950 or 2955 switch. You can have dynamic-access ports and trunk ports on the same switch, but you must connect the dynamic-access port to an end station and not to another switch. For configuration information, see the "Configuring Dynamic Access Ports on VMPS Clients" section on page 15-29.	VTP is required. Configure the VMPS and the client with the same VTP domain name. You can change the reconfirmation interval and retry count on the VMPS client switch.
Voice VLAN	A voice VLAN port is an access port attached to a Cisco IP Phone, configured to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone. For more information about voice VLAN ports, see Chapter 17, "Configuring Voice VLAN."	VTP is not required; it has no affect on voice VLAN.

For more detailed definitions of the modes and their functions, see Table 15-4 on page 15-16.

When a port belongs to a VLAN, the switch learns and manages the addresses associated with the port on a per-VLAN basis. For more information, see the "Managing the MAC Address Table" section on page 8-20.

Configuring Normal-Range VLANs

Normal-range VLANs are VLANs with VLAN IDs 1 to 1005. If the switch is in VTP server or transparent mode, you can add, modify or remove configurations for VLANs 2 to 1001 in the VLAN database. (VLAN IDs 1 and 1002 to 1005 are automatically created and cannot be removed.)

Note When the switch is in VTP transparent mode and the EI is installed, you can also create extended-range VLANs (VLANs with IDs from 1006 to 4094), but these VLANs are not saved in the VLAN database. See the "Configuring Extended-Range VLANs" section on page 15-12.

Configurations for VLAN IDs 1 to 1005 are written to the file *vlan.dat* (VLAN database), and you can display them by entering the **show vlan** privileged EXEC command. The *vlan.dat* file is stored in nonvolatile RAM (NVRAM).

Caution You can cause inconsistency in the VLAN database if you attempt to manually delete the *vlan.dat* file. If you want to modify the VLAN configuration, use the commands described in these sections and in the command reference for this release. To change the VTP configuration, see Chapter 16, "Configuring VTP."

You use the interface configuration mode to define the port membership mode and to add and remove ports from VLANs. The results of these commands are written to the running-configuration file, and you can display the file by entering the **show running-config** privileged EXEC command.

You can set these parameters when you create a new normal-range VLAN or modify an existing VLAN in the VLAN database:

- VLAN ID
- VLAN name
- VLAN type (Ethernet, Fiber Distributed Data Interface [FDDI], FDDI network entity title [NET], TrBRF, or TrCRF, Token Ring, Token Ring-Net)
- VLAN state (active or suspended)
- Maximum transmission unit (MTU) for the VLAN
- Security Association Identifier (SAID)
- Bridge identification number for TrBRF VLANs
- Ring number for FDDI and TrCRF VLANs
- Parent VLAN number for TrCRF VLANs
- Spanning Tree Protocol (STP) type for TrCRF VLANs
- VLAN number to use when translating from one VLAN type to another

Note This section does not provide configuration details for most of these parameters. For complete information on the commands and parameters that control VLAN configuration, refer to the command reference for this release.

This section includes information about these topics about normal-range VLANs:

- Token Ring VLANs, page 15-5
- Normal-Range VLAN Configuration Guidelines, page 15-5
- VLAN Configuration Mode Options, page 15-6
- Saving VLAN Configuration, page 15-7
- Default Ethernet VLAN Configuration, page 15-7
- Creating or Modifying an Ethernet VLAN, page 15-8
- Deleting a VLAN, page 15-10
- Assigning Static-Access Ports to a VLAN, page 15-11

Token Ring VLANs

Although the switch does not support Token Ring connections, a remote device such as a Catalyst 5000 series switch with Token Ring connections could be managed from one of the supported switches. Switches running VTP version 2 advertise information about these Token Ring VLANs:

- Token Ring TrBRF VLANs
- Token Ring TrCRF VLANs

For more information on configuring Token Ring VLANs, refer to the *Catalyst 5000 Series Software Configuration Guide*.

Normal-Range VLAN Configuration Guidelines

Follow these guidelines when creating and modifying normal-range VLANs in your network:

- See Table 15-1 for the maximum number of supported VLANs per switch model. On a switch supporting 250 VLANs, if VTP reports that there are 250 active VLANs, four of the active VLANs (1002 to 1005) are reserved for Token Ring and FDDI.
- Normal-range VLANs are identified with a number between 1 and 1001. VLAN numbers 1002 through 1005 are reserved for Token Ring and FDDI VLANs.
- VLAN configuration for VLANs 1 to 1005 are always saved in the VLAN database. If VTP mode is transparent, VTP and VLAN configuration is also saved in the switch running configuration file.
- The switch also supports VLAN IDs 1006 through 4094 in VTP transparent mode (VTP disabled) when the EI is installed. These are extended-range VLANs and configuration options are limited. Extended-range VLANs are not saved in the VLAN database. See the "Configuring Extended-Range VLANs" section on page 15-12.
- Before you can create a VLAN, the switch must be in VTP server mode or VTP transparent mode. If the switch is a VTP server, you must define a VTP domain or VTP will not function.
- The switch does not support Token Ring or FDDI media. The switch does not forward FDDI, FDDI-Net, TrCRF, or TrBRF traffic, but it does propagate the VLAN configuration through VTP.
- The switch supports 64 spanning-tree instances. If a switch has more active VLANs than supported spanning-tree instances, spanning tree can be enabled on 64 VLANs and is disabled on the remaining VLANs. If you have already used all available spanning-tree instances on a switch, adding another VLAN anywhere in the VTP domain creates a VLAN on that switch that is not running spanning-tree. If you have the default allowed list on the trunk ports of that switch (which

is to allow all VLANs), the new VLAN is carried on all trunk ports. Depending on the topology of the network, this could create a loop in the new VLAN that would not be broken, particularly if there are several adjacent switches that all have run out of spanning-tree instances. You can prevent this possibility by setting allowed lists on the trunk ports of switches that have used up their allocation of spanning-tree instances.

If the number of VLANs on the switch exceeds the number of supported spanning tree instances, we recommend that you configure the IEEE 802.1S Multiple STP (MSTP) on your switch to map multiple VLANs to a single STP instance. For more information about MSTP, see Chapter 13, "Configuring RSTP and MSTP."

VLAN Configuration Mode Options

You can configure normal-range VLANs (with VLAN IDs 1 to 1005) by using these two configuration modes:

- VLAN Configuration in config-vlan Mode, page 15-6

  You access config-vlan mode by entering the **vlan** *vlan-id* global configuration command.

- VLAN Configuration in VLAN Configuration Mode, page 15-6

  You access VLAN database configuration mode by entering the **vlan database** privileged EXEC command.

VLAN Configuration in config-vlan Mode

To access config-vlan mode, enter the **vlan** global configuration command with a VLAN ID. Enter a new VLAN ID to create a VLAN or with an existing VLAN ID to modify the VLAN. You can use the default VLAN configuration (Table 15-2) or enter multiple commands to configure the VLAN. For more information about commands available in this mode, refer to the **vlan** global configuration command description in the command reference for this release. When you have finished the configuration, you must exit config-vlan mode for the configuration to take effect. To display the VLAN configuration, enter the **show vlan** privileged EXEC command.

You must use this config-vlan mode when creating extended-range VLANs (VLAN IDs greater than 1005). See the "Configuring Extended-Range VLANs" section on page 15-12.

VLAN Configuration in VLAN Configuration Mode

To access VLAN configuration mode, enter the **vlan database** privileged EXEC command. Then enter the **vlan** command with a new VLAN ID to create a VLAN or with an existing VLAN ID to modify the VLAN. You can use the default VLAN configuration (Table 15-2) or enter multiple commands to configure the VLAN. For more information about keywords available in this mode, refer to the **vlan** VLAN configuration command description in the command reference for this release. When you have finished the configuration, you must enter **apply** or **exit** for the configuration to take effect. When you enter the **exit** command, it applies all commands and updates the VLAN database. VTP messages are sent to other switches in the VTP domain, and the privileged EXEC mode prompt appears.

Saving VLAN Configuration

The configurations of VLAN IDs 1 to 1005 are always saved in the VLAN database (vlan.dat file). If VTP mode is transparent, they are also saved in the switch running configuration file and you can enter the **copy running-config startup-config** privileged EXEC command to save the configuration in the startup configuration file. You can use the **show running-config vlan** privileged EXEC command to display the switch running configuration file. To display the VLAN configuration, enter the **show vlan** privileged EXEC command.

When you save VLAN and VTP information (including extended-range VLAN configuration information) in the startup configuration file and reboot the switch, the switch configuration is determined as follows:

- If the VTP mode is transparent in the startup configuration, and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.
- If the VTP mode or domain name in the startup configuration does not match the VLAN database, the domain name and VTP mode and configuration for the first 1005 VLANs use the VLAN database information.
- If VTP mode is server, the domain name and VLAN configuration for the first 1005 VLANs use the VLAN database information
- If the switch is running IOS Release 12.1(9)EA1 or later and you use an older startup configuration file to boot up the switch, the configuration file does not contain VTP or VLAN information, and the switch uses the VLAN database configurations.
- If the switch is running an IOS release earlier than 12.1(9)EA1 and you use a startup configuration file from IOS Release 12.1(9)EA1 or later to boot up the switch, the image on the switch does not recognize the VLAN and VTP configurations in the startup configuration file, so the switch uses the VLAN database configuration.

Caution If the VLAN database configuration is used at startup and the startup configuration file contains extended-range VLAN configuration, this information is lost when the system boots up.

Default Ethernet VLAN Configuration

Table 15-2 shows the default configuration for Ethernet VLANs.

Note The switch supports Ethernet interfaces exclusively. Because FDDI and Token Ring VLANs are not locally supported, you only configure FDDI and Token Ring media-specific characteristics for VTP global advertisements to other switches.

Table 15-2 Ethernet VLAN Defaults and Ranges

Parameter	Default	Range
VLAN ID	1	1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed. **Note** Extended-range VLANs (VLAN IDs 1006 to 4094) are not saved in the VLAN database.
VLAN name	*VLANxxxx*, where *xxxx* represents four numeric digits (including leading zeros) equal to the VLAN ID number	No range
802.10 SAID	100001 (100000 plus the VLAN ID)	1–4294967294
MTU size	1500	1500–18190
Translational bridge 1	0	0–1005
Translational bridge 2	0	0–1005
VLAN state	active	active, suspend
Remote SPAN	disabled	enabled, disabled

Creating or Modifying an Ethernet VLAN

Each Ethernet VLAN in the VLAN database has a unique, 4-digit ID that can be a number from 1 to 1001. VLAN IDs 1002 to 1005 are reserved for Token Ring and FDDI VLANs. To create a normal-range VLAN to be added to the VLAN database, assign a number and name to the VLAN.

Note When the switch is in VTP transparent mode and the EI is installed, you can assign VLAN IDs greater than 1006, but they are not added to the VLAN database. See the "Configuring Extended-Range VLANs" section on page 15-12.

For the list of default parameters that are assigned when you add a VLAN, see the "Configuring Normal-Range VLANs" section on page 15-4.

Beginning in privileged EXEC mode, follow these steps to use config-vlan mode to create or modify an Ethernet VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vlan** *vlan-id*	Enter a VLAN ID, and enter config-vlan mode. Enter a new VLAN ID to create a VLAN, or enter an existing VLAN ID to modify a VLAN. **Note** The available VLAN ID range for this command is 1 to 1005 when the SI is installed and 1 to 4094 when the EI is installed. For information about adding VLAN IDs greater than 1005 (extended-range VLANs), see the "Configuring Extended-Range VLANs" section on page 15-12.

	Command	Purpose
Step 3	**name** *vlan-name*	(Optional) Enter a name for the VLAN. If no name is entered for the VLAN, the default is to append the *vlan-id* with leading zeros to the word VLAN. For example, VLAN0004 is a default VLAN name for VLAN 4.
Step 4	**mtu** *mtu-size*	(Optional) Change the MTU size (or other VLAN characteristic).
Step 5	**remote-span**	(Optional) Configure the VLAN as the RSPAN VLAN for a remote SPAN session. For more information on remote SPAN, see Chapter 22, "Configuring SPAN and RSPAN."
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show vlan** {**name** *vlan-name* | **id** *vlan-id*}	Verify your entries.
Step 8	**copy running-config startup config**	(Optional) If the switch is in VTP transparent mode, the VLAN configuration is saved in the running configuration file as well as in the VLAN database. This saves the configuration in the switch startup configuration file.

To return the VLAN name to the default settings, use the **no vlan name**, **no vlan mtu**, or **no remote span** config-vlan commands.

This example shows how to use config-vlan mode to create Ethernet VLAN 20, name it *test20*, and add it to the VLAN database:

```
Switch# configure terminal
Switch(config)# vlan 20
Switch(config-vlan)# name test20
Switch(config-vlan)# end
```

Beginning in privileged EXEC mode, follow these steps to use VLAN configuration mode to create or modify an Ethernet VLAN:

	Command	Purpose
Step 1	**vlan database**	Enter VLAN database configuration mode.
Step 2	**vlan** *vlan-id* **name** *vlan-name*	Add an Ethernet VLAN by assigning a number to it. The range is 1 to 1001; do not enter leading zeros. If no name is entered for the VLAN, the default is to append the *vlan-id* with leading zeros to the word VLAN. For example, VLAN0004 is a default VLAN name for VLAN 4.
Step 3	**vlan** *vlan-id* **mtu** *mtu-size*	(Optional) To modify a VLAN, identify the VLAN and change a characteristic, such as the MTU size.
Step 4	**exit**	Update the VLAN database, propagate it throughout the administrative domain, and return to privileged EXEC mode.
Step 5	**show vlan** {**name** *vlan-name* | **id** *vlan-id*}	Verify your entries.
Step 6	**copy running-config startup config**	(Optional) If the switch is in VTP transparent mode, the VLAN configuration is saved in the running configuration file as well as in the VLAN database. This saves the configuration in the switch startup configuration file.

Note You cannot configure an RSPAN VLAN in VLAN database configuration mode.

To return the VLAN name to the default settings, use the **no vlan** *vlan-id* **name** or **no vlan** *vlan-id* **mtu** VLAN configuration command.

This example shows how to use VLAN database configuration mode to create Ethernet VLAN 20, name it *test20*, and add it to the VLAN database:

```
Switch# vlan database
Switch(vlan)# vlan 20 name test20
Switch(vlan)# exit
APPLY completed.
Exiting....
Switch#
```

Deleting a VLAN

When you delete a VLAN from a switch that is in VTP server mode, the VLAN is removed from the VLAN database for all switches in the VTP domain. When you delete a VLAN from a switch that is in VTP transparent mode, the VLAN is deleted only on that specific switch.

You cannot delete the default VLANs for the different media types: Ethernet VLAN 1 and FDDI or Token Ring VLANs 1002 to 1005.

Caution When you delete a VLAN, any ports assigned to that VLAN become inactive. They remain associated with the VLAN (and thus inactive) until you assign them to a new VLAN.

Beginning in privileged EXEC mode, follow these steps to delete a VLAN on the switch by using global configuration mode:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no vlan** *vlan-id*	Remove the VLAN by entering the VLAN ID.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show vlan brief**	Verify the VLAN removal.
Step 5	**copy running-config startup config**	(Optional) If the switch is in VTP transparent mode, the VLAN configuration is saved in the running configuration file as well as in the VLAN database. This saves the configuration in the switch startup configuration file.

To delete a VLAN when in VLAN database configuration mode, use the **vlan database** privileged EXEC command to enter VLAN database configuration mode and the **no vlan** *vlan-id* VLAN configuration command.

Assigning Static-Access Ports to a VLAN

You can assign a static-access port to a VLAN without having VTP globally propagate VLAN configuration information by disabling VTP (VTP transparent mode). If you are assigning a port on a cluster member switch to a VLAN, first use the **rcommand** privileged EXEC command to log in to the member switch.

Note If you assign an interface to a VLAN that does not exist, the new VLAN is created. (See the "Creating or Modifying an Ethernet VLAN" section on page 15-8.)

Beginning in privileged EXEC mode, follow these steps to assign a port to a VLAN in the VLAN database:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**interface** *interface-id*	Enter the interface to be added to the VLAN.
Step 3	**switchport mode access**	Define the VLAN membership mode for the port (Layer 2 access port).
Step 4	**switchport access vlan** *vlan-id*	Assign the port to a VLAN. Valid VLAN IDs are 1 to 4094.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config interface** *interface-id*	Verify the VLAN membership mode of the interface.
Step 7	**show interfaces** *interface-id* **switchport**	Verify your entries in the *Administrative Mode* and the *Access Mode VLAN* fields of the display.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return an interface to its default configuration, use the **default interface** *interface-id* interface configuration command.

This example shows how to configure Fast Ethernet interface 0/1 as an access port in VLAN 2:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# interface fastethernet0/1
Switch(config-if)# switchport mode access
Switch(config-if)# switchport access vlan 2
Switch(config-if)# end
Switch#
```

Configuring Extended-Range VLANs

When the switch is in VTP transparent mode (VTP disabled) and the EI is installed), you can create extended-range VLANs (in the range 1006 to 4094). Extended-range VLANs enable service providers to extend their infrastructure to a greater number of customers. The extended-range VLAN IDs are allowed for any switchport commands that allow VLAN IDs. You always use config-vlan mode (accessed by entering the **vlan** *vlan-id* global configuration command) to configure extended-range VLANs. The extended range is not supported in VLAN database configuration mode (accessed by entering the **vlan database** privileged EXEC command).

Extended-range VLAN configurations are not stored in the VLAN database, but because VTP mode is transparent, they are stored in the switch running configuration file, and you can save the configuration in the startup configuration file by using the **copy running-config startup-config** privileged EXEC command.

Note Although the switch supports 4094 VLAN IDs when the EI is installed, see the "Supported VLANs" section on page 15-2 for the actual number of VLANs supported.

This section includes this information about extended-range VLANs:

- Default VLAN Configuration, page 15-12
- Extended-Range VLAN Configuration Guidelines, page 15-12
- Creating an Extended-Range VLAN, page 15-13
- Displaying VLANs, page 15-14

Default VLAN Configuration

See Table 15-2 on page 15-8 for the default configuration for Ethernet VLANs. You can change only the MTU size on extended-range VLANs; all other characteristics must remain at the default state.

Extended-Range VLAN Configuration Guidelines

Follow these guidelines when creating extended-range VLANs:

- To add an extended-range VLAN, you must use the **vlan** *vlan-id* global configuration command and access config-vlan mode. You cannot add extended-range VLANs in VLAN database configuration mode (accessed by entering the **vlan database** privileged EXEC command).
- VLAN IDs in the extended range are not saved in the VLAN database and are not recognized by VTP.
- You cannot include extended-range VLANs in the pruning eligible range.
- The switch must be in VTP transparent mode when you create extended-range VLANs. If VTP mode is server or client, an error message is generated, and the extended-range VLAN is rejected.
- You can set the VTP mode to transparent in global configuration mode or in VLAN database configuration mode. See the "Disabling VTP (VTP Transparent Mode)" section on page 16-12. You should save this configuration to the startup configuration so that the switch will boot up in VTP transparent mode. Otherwise, you will lose extended-range VLAN configuration if the switch resets.

- VLANs in the extended range are not supported by VQP. They cannot be configured by VMPS.
- STP is enabled by default on extended-range VLANs, but you can disable it by using the **no spanning-tree vlan** *vlan-id* global configuration command. When the maximum number of spanning-tree instances (64) are on the switch, spanning tree is disabled on any newly created VLANs. If the number of VLANs on the switch exceeds the maximum number of spanning tree instances, we recommend that you configure the IEEE 802.1S Multiple STP (MSTP) on your switch to map multiple VLANs to a single STP instance. For more information about MSTP, see Chapter 13, "Configuring RSTP and MSTP."

Creating an Extended-Range VLAN

You create an extended-range VLAN in global configuration mode by entering the **vlan** global configuration command with a VLAN ID from 1006 to 4094. This command accesses the config-vlan mode. The extended-range VLAN has the default Ethernet VLAN characteristics (see Table 15-2) and the MTU size is the only parameter you can change. Refer to the description of the **vlan** global configuration command in the command reference for defaults of all parameters. If you enter an extended-range VLAN ID when the switch is not in VTP transparent mode, an error message is generated when you exit from config-vlan mode, and the extended-range VLAN is not created.

Extended-range VLANs are not saved in the VLAN database; they are saved in the switch running configuration file. You can save the extended-range VLAN configuration in the switch startup configuration file by using the **copy running-config startup-config** privileged EXEC command.

Note Before you create an extended-range VLAN, you can verify that the VLAN ID is not used internally by entering the **show vlan internal usage** privileged EXEC command. If the VLAN ID is used internally and you want to free it up, go to the"Displaying VLANs" section on page 15-14 before creating the extended-range VLAN.

Beginning in privileged EXEC mode, follow these steps to create an extended-range VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vtp mode transparent**	Configure the switch for VTP transparent mode, disabling VTP.
Step 3	**vlan** *vlan-id*	Enter an extended-range VLAN ID and enter config-vlan mode. The range is 1006 to 4094.
Step 4	**mtu** *mtu-size*	(Optional) Modify the VLAN by changing the MTU size. **Note** Although all commands appear in the CLI help in config-vlan mode, only the **mtu** *mtu-size* command is supported for extended-range VLANs.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show vlan id** *vlan-id*	Verify that the VLAN has been created.
Step 7	**copy running-config startup config**	Save your entries in the switch startup configuration file. To save extended-range VLAN configurations, you need to save the VTP transparent mode configuration and the extended-range VLAN configuration in the switch startup configuration file. Otherwise, if the switch resets, it will default to VTP server mode, and the extended-range VLAN IDs will not be saved.

To delete an extended-range VLAN, use the **no vlan** *vlan-id* global configuration command.

The procedure for assigning static-access ports to an extended-range VLAN is the same as for normal-range VLANs. See the "Assigning Static-Access Ports to a VLAN" section on page 15-11.

This example shows how to create a new extended-range VLAN (when the EI is installed) with all default characteristics, enter config-vlan mode, and save the new VLAN in the switch startup configuration file:

```
Switch(config)# vtp mode transparent
Switch(config)# vlan 2000
Switch(config-vlan)# end
Switch# copy running-config startup config
```

Displaying VLANs

Use the **show vlan** privileged EXEC command to display a list of all VLANs on the switch, including extended-range VLANs. The display includes VLAN status, ports, and configuration information. To view normal-range VLANs in the VLAN database (1 to 1005,) use the **show** VLAN configuration command (accessed by entering the **vlan database** privileged EXEC command). For a list of the VLAN IDs on the switch, use the **show running-config vlan** privileged EXEC command, optionally entering a VLAN ID range.

Table 15-3 lists the commands for monitoring VLANs.

Table 15-3 VLAN Monitoring Commands

Command	Command Mode	Purpose
show	VLAN configuration	Display status of VLANs in the VLAN database.
show current [*vlan-id*]	VLAN configuration	Display status of all or the specified VLAN in the VLAN database.
show interfaces [**vlan** *vlan-id*]	Privileged EXEC	Display characteristics for all interfaces or for the specified VLAN configured on the switch.
show running-config vlan	Privileged EXEC	Display all or a range of VLANs on the switch.
show vlan [**id** *vlan-id*]	Privileged EXEC	Display parameters for all VLANs or the specified VLAN on the switch.

For more details about the show command options and explanations of output fields, refer to the command reference for this release.

Configuring VLAN Trunks

These sections describe how VLAN trunks function on the switch:

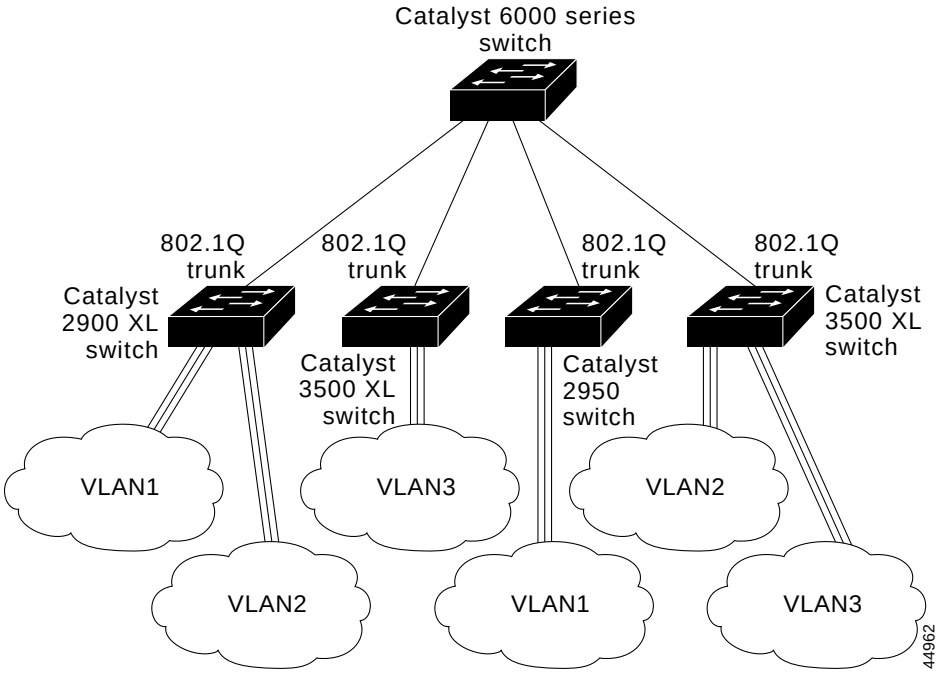
- Trunking Overview, page 15-15
- 802.1Q Configuration Considerations, page 15-16
- Default Layer 2 Ethernet Interface VLAN Configuration, page 15-17

Trunking Overview

A trunk is a point-to-point link between one or more Ethernet switch interfaces and another networking device such as a router or a switch. Fast Ethernet and Gigabit Ethernet trunks carry the traffic of multiple VLANs over a single link, and you can extend the VLANs across an entire network.

Figure 15-2 shows a network of switches that are connected by 802.1Q trunks.

Figure 15-2 Catalyst 2950, 2900 XL, and 3500 XL Switches in a 802.1Q Trunking Environment



You can configure a trunk on a single Ethernet interface or on an EtherChannel bundle. For more information about EtherChannel, see Chapter 28, "Configuring EtherChannels."

Ethernet trunk interfaces support different trunking modes (see Table 15-4). You can set an interface as trunking or nontrunking or to negotiate trunking with the neighboring interface. To autonegotiate trunking, the interfaces must be in the same VTP domain.

Trunk negotiation is managed by the Dynamic Trunking Protocol (DTP), which is a Point-to-Point Protocol. However, some internetworking devices might forward DTP frames improperly, which could cause misconfigurations.

To avoid this, you should configure interfaces connected to devices that do not support DTP to not forward DTP frames, that is, to turn off DTP.

- If you do not intend to trunk across those links, use the **switchport mode access** interface configuration command to disable trunking.
- To enable trunking to a device that does not support DTP, use the **switchport mode trunk** and **switchport nonegotiate** interface configuration commands to cause the interface to become a trunk but to not generate DTP frames.

Note On GigaStack GBICs, dynamic trunking is only supported when only one port of a GigaStack GBIC is being used. If trunking is required on a GigaStack GBIC where both ports are in use, use the **switchport mode trunk** and **switchport nonegotiate** interface configuration commands on both GBIC interfaces to cause the interfaces to become trunks.

Table 15-4 Layer 2 Interface Modes

Mode	Function
switchport mode access	Puts the interface (access port) into permanent nontrunking mode and negotiates to convert the link into a nontrunk link. The interface becomes a nontrunk interface even if the neighboring interface is not a trunk interface.
switchport mode dynamic desirable	Makes the interface actively attempt to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to *trunk*, *desirable*, or *auto* mode. The default switch-port mode for all Ethernet interfaces is **dynamic desirable**.
switchport mode dynamic auto	Makes the interface able to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to *trunk* or *desirable* mode.
switchport mode trunk	Puts the interface into permanent trunking mode and negotiates to convert the link into a trunk link. The interface becomes a trunk interface even if the neighboring interface is not a trunk interface.
switchport nonegotiate	Prevents the interface from generating DTP frames. You can use this command only when the interface switchport mode is **access** or **trunk**. You must manually configure the neighboring interface as a trunk interface to establish a trunk link.

802.1Q Configuration Considerations

802.1Q trunks impose these limitations on the trunking strategy for a network:

- In a network of Cisco switches connected through 802.1Q trunks, the switches maintain one instance of spanning tree for each VLAN allowed on the trunks. Non-Cisco devices might support one spanning-tree instance for all VLANs.

  When you connect a Cisco switch to a non-Cisco device through an 802.1Q trunk, the Cisco switch combines the spanning-tree instance of the VLAN of the trunk with the spanning-tree instance of the non-Cisco 802.1Q switch. However, spanning-tree information for each VLAN is maintained by Cisco switches separated by a cloud of non-Cisco 802.1Q switches. The non-Cisco 802.1Q cloud separating the Cisco switches is treated as a single trunk link between the switches.

- Make sure the native VLAN for an 802.1Q trunk is the same on both ends of the trunk link. If the native VLAN on one end of the trunk is different from the native VLAN on the other end, spanning-tree loops might result.
- Disabling spanning tree on the native VLAN of an 802.1Q trunk without disabling spanning tree on every VLAN in the network can potentially cause spanning-tree loops. We recommend that you leave spanning tree enabled on the native VLAN of an 802.1Q trunk or disable spanning tree on every VLAN in the network. Make sure your network is loop-free before disabling spanning tree.

Default Layer 2 Ethernet Interface VLAN Configuration

Table 15-5 shows the default Layer 2 Ethernet interface VLAN configuration.

Table 15-5 Default Layer 2 Ethernet Interface VLAN Configuration

Feature	Default Setting
Interface mode	**switchport mode dynamic desirable**
Allowed VLAN range	VLANs 1 to 4094 when the EI is installed and 1 to 1005 when the SI is installed
VLAN range eligible for pruning	VLANs 2 to 1001
Default VLAN (for access ports)	VLAN 1
Native VLAN (for 802.1Q trunks)	VLAN 1

Configuring an Ethernet Interface as a Trunk Port

Because trunk ports send and receive VTP advertisements, to use VTP you must ensure that at least one trunk port is configured on the switch and that this trunk port is connected to the trunk port of a second switch. Otherwise, the switch cannot receive any VTP advertisements.

This section includes these procedures for configuring an Ethernet interface as a trunk port on the switch:

- Interaction with Other Features, page 15-18
- Defining the Allowed VLANs on a Trunk, page 15-19
- Changing the Pruning-Eligible List, page 15-20
- Configuring the Native VLAN for Untagged Traffic, page 15-21

Note The default mode for Layer 2 interfaces is **switchport mode dynamic desirable**. If the neighboring interface supports trunking and is configured to allow trunking, the link is a Layer 2 trunk.

Interaction with Other Features

Trunking interacts with other features in these ways:

- A trunk port cannot be a secure port.
- Trunk ports can be grouped into EtherChannel port groups, but all trunks in the group must have the same configuration. When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, the switch propagates the setting you entered to all ports in the group:
  - allowed-VLAN list
  - STP port priority for each VLAN
  - STP Port Fast setting
  - trunk status: if one port in a port group ceases to be a trunk, all ports cease to be trunks.
- If you try to enable 802.1X on a trunk port, an error message appears, and 802.1X is not enabled. If you try to change the mode of an 802.1X-enabled port to trunk, the port mode is not changed.
- A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable 802.1X on a dynamic port, an error message appears, and 802.1X is not enabled. If you try to change the mode of an 802.1X-enabled port to dynamic, the port mode is not changed.

Configuring a Trunk Port

Beginning in privileged EXEC mode, follow these steps to configure a port as 802.1Q trunk port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter the interface configuration mode and the port to be configured for trunking.
Step 3	**switchport mode** {**dynamic** {**auto** | **desirable**} | **trunk**}	Configure the interface as a Layer 2 trunk (required only if the interface is a Layer 2 access port or to specify the trunking mode). • **dynamic auto**—Set the interface to a trunk link if the neighboring interface is set to trunk or desirable mode. • **dynamic desirable**—Set the interface to a trunk link if the neighboring interface is set to trunk, desirable, or auto mode. • **trunk**—Set the interface in permanent trunking mode and negotiate to convert the link to a trunk link even if the neighboring interface is not a trunk interface.
Step 4	**switchport access vlan** *vlan-id*	(Optional) Specify the default VLAN, which is used if the interface stops trunking.
Step 5	**switchport trunk native vlan** *vlan-id*	Specify the native VLAN.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show interfaces** *interface-id* **switchport**	Display the switchport configuration of the interface in the *Administrative Mode* and the *Administrative Trunking Encapsulation* fields of the display.

	Command	Purpose
Step 8	**show interfaces** *interface-id* **trunk**	Display the trunk configuration of the interface.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return an interface to its default configuration, use the **default interface** *interface-id* interface configuration command. To reset all trunking characteristics of a trunking interface to the defaults, use the **no switchport trunk** interface configuration command. To disable trunking, use the **switchport mode access** interface configuration command to configure the port as a static-access port.

This example shows how to configure the Fast Ethernet interface 0/4 as an 802.1Q trunk. The example assumes that the neighbor interface is configured to support 802.1Q trunking.

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# interface fastethernet0/4
Switch(config-if)# switchport mode dynamic desirable
Switch(config-if)# end
```

Defining the Allowed VLANs on a Trunk

By default, a trunk port sends traffic to and receives traffic from all VLANs. All VLAN IDs, 1 to 4094 when the EI is installed, and 1 to 1005 when the SI is installed, are allowed on each trunk. However, you can remove VLANs from the allowed list, preventing traffic from those VLANs from passing over the trunk. To restrict the traffic a trunk carries, use the **switchport trunk allowed vlan remove** *vlan-list* interface configuration command to remove specific VLANs from the allowed list.

Note You cannot remove VLAN 1 or VLANs 1002 to 1005 from the allowed VLAN list.

A trunk port can become a member of a VLAN if the VLAN is enabled, if VTP knows of the VLAN, and if the VLAN is in the allowed list for the port. When VTP detects a newly enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of the enabled VLAN. When VTP detects a new VLAN and the VLAN is not in the allowed list for a trunk port, the trunk port does not become a member of the new VLAN.

Beginning in privileged EXEC mode, follow these steps to modify the allowed list of an 802.1Q trunk:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode and the port to be configured.
Step 3	**switchport mode trunk**	Configure the interface as a VLAN trunk port.
Step 4	**switchport trunk allowed vlan** {**add** | **all** | **except** | **remove**} *vlan-list*	(Optional) Configure the list of VLANs allowed on the trunk. For explanations about using the **add**, **all**, **except**, and **remove** keywords, refer to the command reference for this release. The *vlan-list* parameter is either a single VLAN number from 1 to 4094 or a range of VLANs described by two VLAN numbers, the lower one first, separated by a hyphen. Do not enter any spaces between comma-separated VLAN parameters or in hyphen-specified ranges. All VLANs are allowed by default. You cannot remove any of the default VLANs (1 or 1002 to 1005) from a trunk.

	Command	Purpose
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show interfaces** *interface-id* **switchport**	Verify your entries in the *Trunking VLANs Enabled* field of the display.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default allowed VLAN list of all VLANs, use the **no switchport trunk allowed vlan** interface configuration command.

This example shows how to remove VLAN 2 from the allowed VLAN list:

```
Switch(config)# interface fastethernet0/1
Switch(config-if)# switchport trunk allowed vlan remove 2
Switch(config-if)# end
Switch#
```

Changing the Pruning-Eligible List

The pruning-eligible list applies only to trunk ports. Each trunk port has its own eligibility list. VTP pruning must be enabled for this procedure to take effect. The "Enabling VTP Pruning" section on page 16-14 describes how to enable VTP pruning.

Beginning in privileged EXEC mode, follow these steps to remove VLANs from the pruning-eligible list on a trunk port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and select the trunk port for which VLANs should be pruned.
Step 3	**switchport trunk pruning vlan** {**add** | **except** | **none** | **remove**} *vlan-list* [,*vlan*[,*vlan*[,,,]]	Configure the list of VLANs allowed to be pruned from the trunk. (See the "VTP Pruning" section on page 16-4). For explanations about using the **add**, **except**, **none**, and **remove** keywords, refer to the command reference for this release. Separate nonconsecutive VLAN IDs with a comma and no spaces; use a hyphen to designate a range of IDs. Valid IDs are from 2 to 1001. Extended-range VLANs (VLAN IDs 1006 to 4094) cannot be pruned. VLANs that are pruning-ineligible receive flooded traffic. The default list of VLANs allowed to be pruned contains VLANs 2 to 1001.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your entries in the *Pruning VLANs Enabled* field of the display.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default pruning-eligible list of all VLANs, use the **no switchport trunk pruning vlan** interface configuration command.

Configuring the Native VLAN for Untagged Traffic

A trunk port configured with 802.1Q tagging can receive both tagged and untagged traffic. By default, the switch forwards untagged traffic in the native VLAN configured for the port. The native VLAN is VLAN 1 by default.

Note The native VLAN can be assigned any VLAN ID; it is not dependent on the management VLAN.

For information about 802.1Q configuration issues, see the "802.1Q Configuration Considerations" section on page 15-16.

Beginning in privileged EXEC mode, follow these steps to configure the native VLAN on an 802.1Q trunk:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and define the interface that is configured as the 802.1Q trunk.
Step 3	**switchport trunk native vlan** *vlan-id*	Configure the VLAN that is sending and receiving untagged traffic on the trunk port. For *vlan-id*, the range is 1 to 4094 when the EI is installed, and 1 to 1005 when the SI is installed.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your entries in the *Trunking Native Mode VLAN* field.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default native VLAN, VLAN 1, use the **no switchport trunk native vlan** interface configuration command.

If a packet has a VLAN ID that is the same as the outgoing port native VLAN ID, the packet is sent untagged; otherwise, the switch sends the packet with a tag.

Load Sharing Using STP

Load sharing divides the bandwidth supplied by parallel trunks connecting switches. To avoid loops, STP normally blocks all but one parallel link between switches. Using load sharing, you divide the traffic between the links according to which VLAN the traffic belongs.

You configure load sharing on trunk ports by using STP port priorities or STP path costs. For load sharing using STP port priorities, both load-sharing links must be connected to the same switch. For load sharing using STP path costs, each load-sharing link can be connected to the same switch or to two different switches. For more information about STP, see Chapter 12, "Configuring STP."

Load Sharing Using STP Port Priorities

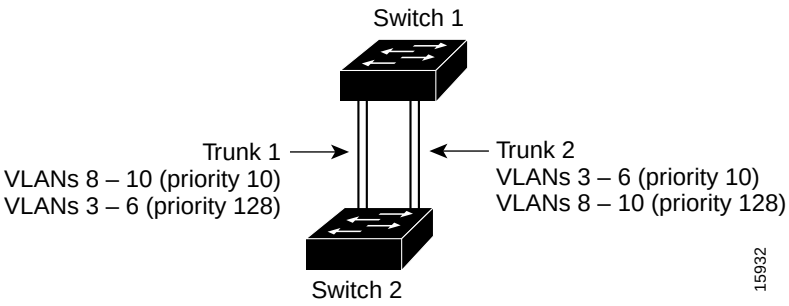
When two ports on the same switch form a loop, the STP port priority setting determines which port is enabled and which port is in a blocking state. You can set the priorities on a parallel trunk port so that the port carries all the traffic for a given VLAN. The trunk port with the higher priority (lower values) for a VLAN is forwarding traffic for that VLAN. The trunk port with the lower priority (higher values) for the same VLAN remains in a blocking state for that VLAN. One trunk port sends or receives all traffic for the VLAN.

Figure 15-3 shows two trunks connecting supported switches. In this example, the switches are configured as follows:

- VLANs 8 through 10 are assigned a port priority of 10 on Trunk 1.
- VLANs 3 through 6 retain the default port priority of 128 on Trunk 1.
- VLANs 3 through 6 are assigned a port priority of 10 on Trunk 2.
- VLANs 8 through 10 retain the default port priority of 128 on Trunk 2.

In this way, Trunk 1 carries traffic for VLANs 8 through 10, and Trunk 2 carries traffic for VLANs 3 through 6. If the active trunk fails, the trunk with the lower priority takes over and carries the traffic for all of the VLANs. No duplication of traffic occurs over any trunk port.

Figure 15-3 Load Sharing by Using STP Port Priorities



Beginning in privileged EXEC mode, follow these steps to configure the network shown in Figure 15-3.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode on Switch 1.
Step 2	**vtp domain** *domain-name*	Configure a VTP administrative domain. The domain name can be from 1 to 32 characters.
Step 3	**vtp mode server**	Configure Switch 1 as the VTP server.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show vtp status**	Verify the VTP configuration on both Switch 1 and Switch 2. In the display, check the *VTP Operating Mode* and the *VTP Domain Name* fields.
Step 6	**show vlan**	Verify that the VLANs exist in the database on Switch 1.
Step 7	**configure terminal**	Enter global configuration mode.
Step 8	**interface fastethernet 0/1**	Enter interface configuration mode, and define Fast Ethernet port 0/1 as the interface to be configured as a trunk.

	Command	Purpose
Step 9	**switchport mode trunk**	Configure the port as a trunk port.
Step 10	**end**	Return to privilege EXEC mode.
Step 11	**show interfaces fastethernet0/1 switchport**	Verify the VLAN configuration.
Step 12		Repeat Steps 7 through 11 on Switch 1 for Fast Ethernet port 0/2.
Step 13		Repeat Steps 7 through 11 on Switch 2 to configure the trunk ports on Fast Ethernet ports 0/1 and 0/2.
Step 14	**show vlan**	When the trunk links come up, VTP passes the VTP and VLAN information to Switch 2. Verify that Switch 2 has learned the VLAN configuration.
Step 15	**configure terminal**	Enter global configuration mode on Switch 1.
Step 16	**interface fastethernet0/1**	Enter interface configuration mode, and define the interface to set the STP port priority.
Step 17	**spanning-tree vlan 8 port-priority 10**	Assign the port priority of 10 for VLAN 8.
Step 18	**spanning-tree vlan 9 port-priority 10**	Assign the port priority of 10 for VLAN 9.
Step 19	**spanning-tree vlan 10 port-priority 10**	Assign the port priority of 10 for VLAN 10.
Step 20	**exit**	Return to global configuration mode.
Step 21	**interface fastethernet0/2**	Enter interface configuration mode, and define the interface to set the STP port priority.
Step 22	**spanning-tree vlan 3 port-priority 10**	Assign the port priority of 10 for VLAN 3.
Step 23	**spanning-tree vlan 4 port-priority 10**	Assign the port priority of 10 for VLAN 4.
Step 24	**spanning-tree vlan 5 port-priority 10**	Assign the port priority of 10 for VLAN 5.
Step 25	**spanning-tree vlan 6 port-priority 10**	Assign the port priority of 10 for VLAN 6.
Step 26	**end**	Return to privileged EXEC mode.
Step 27	**show running-config**	Verify your entries.
Step 28	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

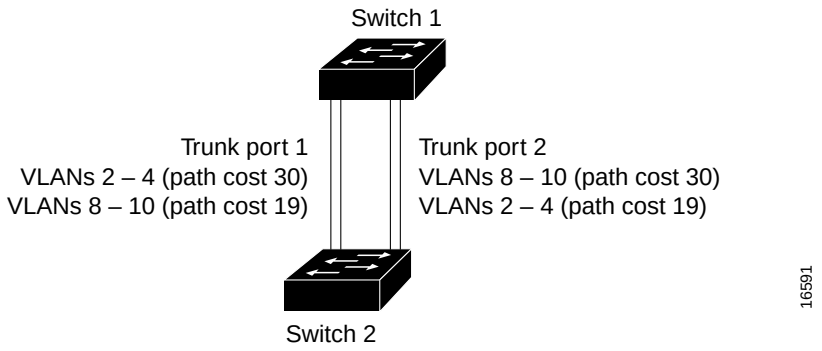
Load Sharing Using STP Path Cost

You can configure parallel trunks to share VLAN traffic by setting different path costs on a trunk and associating the path costs with different sets of VLANs. The VLANs keep the traffic separate. Because no loops exist, STP does not disable the ports, and redundancy is maintained in the event of a lost link.

In Figure 15-4, Trunk ports 1 and 2 are 100BASE-T ports. The path costs for the VLANs are assigned as follows:

- VLANs 2 through 4 are assigned a path cost of 30 on Trunk port 1.
- VLANs 8 through 10 retain the default 100BASE-T path cost on Trunk port 1 of 19.
- VLANs 8 through 10 are assigned a path cost of 30 on Trunk port 2.
- VLANs 2 through 4 retain the default 100BASE-T path cost on Trunk port 2 of 19.

Figure 15-4 Load-Sharing Trunks with Traffic Distributed by Path Cost


Switch 1
Trunk port 1
VLANs 2 – 4 (path cost 30)
VLANs 8 – 10 (path cost 19)
Trunk port 2
VLANs 8 – 10 (path cost 30)
VLANs 2 – 4 (path cost 19)
Switch 2
16591

Beginning in privileged EXEC mode, follow these steps to configure the network shown in Figure 15-4:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode on Switch 1.
Step 2	**interface fastethernet 0/1**	Enter interface configuration mode, and define Fast Ethernet port 0/1 as the interface to be configured as a trunk.
Step 3	**switchport mode trunk**	Configure the port as a trunk port.
Step 4	**exit**	Return to global configuration mode.
Step 5		Repeat Steps 2 through 4 on Switch 1 interface Fast Ethernet 0/2.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify your entries. In the display, make sure that interfaces Fast Ethernet 0/1 and Fast Ethernet 0/2 are configured as trunk ports.
Step 8	**show vlan**	When the trunk links come up, Switch 1 receives the VTP information from the other switches. Verify that Switch 1 has learned the VLAN configuration.
Step 9	**configure terminal**	Enter global configuration mode.
Step 10	**interface fastethernet 0/1**	Enter interface configuration mode, and define Fast Ethernet port 0/1 as the interface to set the STP cost.
Step 11	**spanning-tree vlan 2 cost 30**	Set the spanning-tree path cost to 30 for VLAN 2.
Step 12	**spanning-tree vlan 3 cost 30**	Set the spanning-tree path cost to 30 for VLAN 3.
Step 13	**spanning-tree vlan 4 cost 30**	Set the spanning-tree path cost to 30 for VLAN 4.
Step 14	**end**	Return to global configuration mode.
Step 15		Repeat Steps 9 through 11 on Switch 1 interface Fast Ethernet 0/2, and set the spanning-tree path cost to 30 for VLANs 8, 9, and 10.
Step 16	**exit**	Return to privileged EXEC mode.
Step 17	**show running-config**	Verify your entries. In the display, verify that the path costs are set correctly for interfaces Fast Ethernet 0/1 and 0/2.
Step 18	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Configuring VMPS

The switch cannot be a VMPS server but can act as a client to the VMPS and communicate with it through the VLAN Query Protocol (VQP). VMPS dynamically assigns dynamic access port VLAN membership.

This section includes this information about configuring VMPS:

- "Understanding VMPS" section on page 15-25
- "Default VMPS Configuration" section on page 15-28
- "VMPS Configuration Guidelines" section on page 15-28
- "Configuring the VMPS Client" section on page 15-29
- "Monitoring the VMPS" section on page 15-31
- "Troubleshooting Dynamic Port VLAN Membership" section on page 15-32
- "VMPS Configuration Example" section on page 15-32

Understanding VMPS

When the VMPS receives a VQP request from a client switch, it searches its database for a MAC-address-to-VLAN mapping. The server response is based on this mapping and whether or not the server is in secure mode. Secure mode determines whether the server shuts down the port when a VLAN is not allowed on it or just denies the port access to the VLAN.

In response to a request, the VMPS takes one of these actions:

- If the assigned VLAN is restricted to a group of ports, the VMPS verifies the requesting port against this group and responds as follows:
  - If the VLAN is allowed on the port, the VMPS sends the VLAN name to the client in response.
  - If the VLAN is not allowed on the port and the VMPS is not in secure mode, the VMPS sends an *access-denied* response.
  - If the VLAN is not allowed on the port and the VMPS is in secure mode, the VMPS sends a *port-shutdown* response.
- If the VLAN in the database does not match the current VLAN on the port and active hosts exist on the port, the VMPS sends an *access-denied* or a *port-shutdown* response, depending on the secure mode of the VMPS.

If the switch receives an *access-denied* response from the VMPS, it continues to block traffic from the MAC address to or from the port. The switch continues to monitor the packets directed to the port and sends a query to the VMPS when it identifies a new address. If the switch receives a *port-shutdown* response from the VMPS, it disables the port. The port must be manually re-enabled by using the CLI, CMS, or SNMP.

You can also use an explicit entry in the configuration table to deny access to specific MAC addresses for security reasons. If you enter the **none** keyword for the VLAN name, the VMPS sends an *access-denied* or *port-shutdown* response, depending on the VMPS secure mode setting.

Dynamic Port VLAN Membership

A dynamic (nontrunking) port on the switch can belong to only one VLAN, with a VLAN ID from 1 to 1005. When the link comes up, the switch does not forward traffic to or from this port until the VMPS provides the VLAN assignment. The VMPS receives the source MAC address from the first packet of a new host connected to the dynamic port and attempts to match the MAC address to a VLAN in the VMPS database.

If there is a match, the VMPS sends the VLAN number for that port. If the client switch was not previously configured, it uses the domain name from the first VTP packet it receives on its trunk port from the VMPS. If the client switch was previously configured, it includes its domain name in the query packet to the VMPS to obtain its VLAN number. The VMPS verifies that the domain name in the packet matches its own domain name before accepting the request and responds to the client with the assigned VLAN number for the client. If there is no match, the VMPS either denies the request or shuts down the port (depending on the VMPS secure mode setting).

Multiple hosts (MAC addresses) can be active on a dynamic port if they are all in the same VLAN; however, the VMPS shuts down a dynamic port if more than 20 hosts are active on the port.

If the link goes down on a dynamic port, the port returns to an isolated state and does not belong to a VLAN. Any hosts that come online through the port are checked again through the VQP with the VMPS before the port is assigned to a VLAN.

VMPS Database Configuration File

The VMPS contains a database configuration file that you create. This ASCII text file is stored on a switch-accessible TFTP server that functions as a server for VMPS. The file contains VMPS information, such as the domain name, the fallback VLAN name, and the MAC-address-to-VLAN mapping. The switch cannot act as the VMPS, but you can use a Catalyst 5000 or Catalyst 6000 series switch as the VMPS.

You can configure a fallback VLAN name. If you connect a device with a MAC address that is not in the database, the VMPS sends the fallback VLAN name to the client. If you do not configure a fallback VLAN and the MAC address does not exist in the database, the VMPS sends an *access-denied* response. If the VMPS is in secure mode, it sends a *port-shutdown* response.

Whenever port names are used in the VMPS database configuration file, the server must use the switch convention for naming ports. For example, Fa0/4 is fixed Fast Ethernet port number 4. If the switch is a cluster member, the command switch adds the name of the switch before the type. For example, *es3%Fa0/4* refers to fixed Fast Ethernet port 4 on member switch 3. When port names are required, these naming conventions must be followed in the VMPS database configuration file when it is configured to support a cluster.

This example shows a example of a VMPS database configuration file as it appears on a Catalyst 6000 series switch. The file has these characteristics:

- The security mode is open.
- The default is used for the fallback VLAN.
- MAC address-to-VLAN name mappings—The MAC address of each host and the VLAN to which each host belongs is defined.
- Port groups are defined.
- VLAN groups are defined.
- VLAN port policies are defined for the ports associated with restricted VLANs.

```
!VMPS File Format, version 1.1
! Always begin the configuration file with
! the word “VMPS”
!
!vmps domain <domain-name>
! The VMPS domain must be defined.
!vmps mode {open | secure}
! The default mode is open.
!vmps fallback <vlan-name>
!vmps no-domain-req { allow | deny }
!
! The default value is allow.
vmps domain DSBU
vmps mode open
vmps fallback default
vmps no-domain-req deny
!
!
!MAC Addresses
!
vmps-mac-addrs
!
! address <addr> vlan-name <vlan_name>
!
address 0012.2233.4455 vlan-name hardware
address 0000.6509.a080 vlan-name hardware
address aabb.ccdd.eeff vlan-name Green
address 1223.5678.9abc vlan-name ExecStaff
address fedc.ba98.7654 vlan-name --NONE--
address fedc.ba23.1245 vlan-name Purple
!
!Port Groups
!
!vmps-port-group <group-name>
! device <device-id> { port <port-name> | all-ports }
!
vmps-port-group WiringCloset1
 device 198.92.30.32 port 0/2
 device 172.20.26.141 port 0/8
vmps-port-group “Executive Row”
 device 198.4.254.222 port 0/2
 device 198.4.254.222 port 0/3
 device 198.4.254.223 all-ports
!
!
!VLAN groups
!
!vmps-vlan-group <group-name>
! vlan-name <vlan-name>
!
vmps-vlan-group Engineering
vlan-name hardware
vlan-name software
!
!
!VLAN port Policies
!
!vmps-port-policies {vlan-name <vlan_name> | vlan-group <group-name> }
! { port-group <group-name> | device <device-id> port <port-name> }
!
vmps-port-policies vlan-group Engineering
 port-group WiringCloset1
```

```
vmps-port-policies vlan-name Green
 device 198.92.30.32 port 0/8
vmps-port-policies vlan-name Purple
 device 198.4.254.22 port 0/2
 port-group “Executive Row”
```

Default VMPS Configuration

Table 15-6 shows the default VMPS and dynamic port configuration on client switches.

Table 15-6 Default VMPS Client and Dynamic Port Configuration

Feature	Default Setting
VMPS domain server	None
VMPS reconfirm interval	60 minutes
VMPS server retry count	3
Dynamic ports	None configured

VMPS Configuration Guidelines

These guidelines and restrictions apply to dynamic access port VLAN membership:

- You should configure the VMPS before you configure ports as dynamic.
- The communication between a cluster of switches and VMPS is managed by the command switch and includes port-naming conventions that are different from standard port names. For the cluster-based port-naming conventions, see the “VMPS Database Configuration File” section on page 15-26.
- When you configure a port as a dynamic access port, the spanning-tree Port Fast feature is automatically enabled for that port. The Port Fast mode accelerates the process of bringing the port into the forwarding state.
- 802.1X ports cannot be configured as dynamic access ports. If you try to enable 802.1X on a dynamic-access (VQP) port, an error message appears, and 802.1X is not enabled. If you try to change an 802.1X-enabled port to dynamic VLAN assignment, an error message appears, and the VLAN configuration is not changed.
- Trunk ports cannot be dynamic access ports, but you can enter the **switchport access vlan dynamic** interface configuration command for a trunk port. In this case, the switch retains the setting and applies it if the port is later configured as an access port.

  You must turn off trunking on the port before the dynamic access setting takes effect.
- Dynamic access ports cannot be network ports or monitor ports.
- Secure ports cannot be dynamic access ports. You must disable port security on a port before it becomes dynamic.
- Dynamic access ports cannot be members of an EtherChannel group.
- Port channels cannot be configured as dynamic access ports.
- The VTP management domain of the VMPS client and the VMPS server must be the same.

- VQP does not support extended-range VLANs (VLAN IDs higher than 1006). Extended-range VLANs cannot be configured by VMPS.
- The VLAN configured on the VMPS server should not be a voice VLAN.

Configuring the VMPS Client

You configure dynamic VLANs by using the VMPS (server). The switch can be a VMPS client; it cannot be a VMPS server.

Entering the IP Address of the VMPS

You must first enter the IP address of the server to configure the switch as a client.

Note If the VMPS is being defined for a cluster of switches, enter the address on the command switch.

Beginning in privileged EXEC mode, follow these steps to enter the IP address of the VMPS:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vmps server** *ipaddress* **primary**	Enter the IP address of the switch acting as the primary VMPS server.
Step 3	**vmps server** *ipaddress*	Enter the IP address of the switch acting as a secondary VMPS server. You can enter up to three secondary server addresses.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show vmps**	Verify your entries in the *VMPS Domain Server* field of the display.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note The switch port that is connected to the VMPS server cannot be a dynamic access port. It can be either a static access port or a trunk port. See the "Configuring an Ethernet Interface as a Trunk Port" section on page 15-17.

Configuring Dynamic Access Ports on VMPS Clients

If you are configuring a port on a cluster member switch as a dynamic port, first use the **rcommand** privileged EXEC command to log into the member switch.

Caution Dynamic port VLAN membership is for end stations or hubs connected to end stations. Connecting dynamic access ports to other switches can cause a loss of connectivity.

Beginning in privileged EXEC mode, follow these steps to configure a dynamic access port on a VMPS client switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode and the switch port that is connected to the end station.
Step 3	**switchport mode access**	Set the port to access mode.
Step 4	**switchport access vlan dynamic**	Configure the port as eligible for dynamic VLAN membership. The dynamic access port must be connected to an end station.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show interfaces** *interface-id* **switchport**	Verify your entries in the *Operational Mode* field of the display.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return an interface to its default configuration, use the **default interface** *interface-id* interface configuration command. To return an interface to its default switchport mode (dynamic desirable), use the **no switchport mode** interface configuration command. To reset the access mode to the default VLAN for the switch, use the **no switchport access** interface configuration command.

Note When you configure a dynamic access port by using the **switchport access vlan dynamic** interface configuration command, the port might allow unauthorized users to access network resources if the interface changes from access mode to trunk mode through the DTP negotiation. The workaround is to configure the port as a static access port.

Reconfirming VLAN Memberships

Beginning in privileged EXEC mode, follow these steps to confirm the dynamic port VLAN membership assignments that the switch has received from the VMPS:

	Command	Purpose
Step 1	**vmps reconfirm**	Reconfirm dynamic port VLAN membership.
Step 2	**show vmps**	Verify the dynamic VLAN reconfirmation status.

Changing the Reconfirmation Interval

VMPS clients periodically reconfirm the VLAN membership information received from the VMPS. You can set the number of minutes after which reconfirmation occurs.

If you are configuring a member switch in a cluster, this parameter must be equal to or greater than the reconfirmation setting on the command switch. You must also first use the **rcommand** privileged EXEC command to log into the member switch.

Beginning in privileged EXEC mode, follow these steps to change the reconfirmation interval:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vmps reconfirm** *minutes*	Enter the number of minutes between reconfirmations of the dynamic VLAN membership. Enter a number from 1 to 120. The default is 60 minutes.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show vmps**	Verify the dynamic VLAN reconfirmation status in the *Reconfirm Interval* field of the display.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no vmps reconfirm** global configuration command.

Changing the Retry Count

Beginning in privileged EXEC mode, follow these steps to change the number of times that the switch attempts to contact the VMPS before querying the next server:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vmps retry** *count*	Change the retry count. The retry range is from 1 to 10; the default is 3.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show vmps**	Verify your entry in the *Server Retry Count* field of the display.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default setting, use the **no vmps retry** global configuration command.

Monitoring the VMPS

You can display information about the VMPS by using the **show vmps** privileged EXEC command. The switch displays this information about the VMPS:

VMPS VQP Version — The version of VQP used to communicate with the VMPS. The switch queries the VMPS that is using VQP version 1.

Reconfirm Interval — The number of minutes the switch waits before reconfirming the VLAN-to-MAC-address assignments.

Server Retry Count — The number of times VQP resends a query to the VMPS. If no response is received after this many tries, the switch starts to query the secondary VMPS.

VMPS domain server	The IP address of the configured VLAN membership policy servers. The switch sends queries to the one marked *current*. The one marked *primary* is the primary server.
VMPS Action	The result of the most recent reconfirmation attempt. A reconfirmation attempt can occur automatically when the reconfirmation interval expired, or you can force it by entering the **vmps reconfirm** privileged EXEC command or its CMS or SNMP equivalent.

This is an example of output for the **show vmps** privileged EXEC command:

```
Switch# show vmps

VQP Client Status:
--------------------
VMPS VQP Version:   1
Reconfirm Interval: 60 min
Server Retry Count: 3
VMPS domain server: 172.20.128.86 (primary, current)
                    172.20.128.87

Reconfirmation status
---------------------
VMPS Action:         No Dynamic Port
```

Troubleshooting Dynamic Port VLAN Membership

The VMPS shuts down a dynamic port under these conditions:

- The VMPS is in secure mode, and it does not allow the host to connect to the port. The VMPS shuts down the port to prevent the host from connecting to the network.
- More than 20 active hosts reside on a dynamic port.

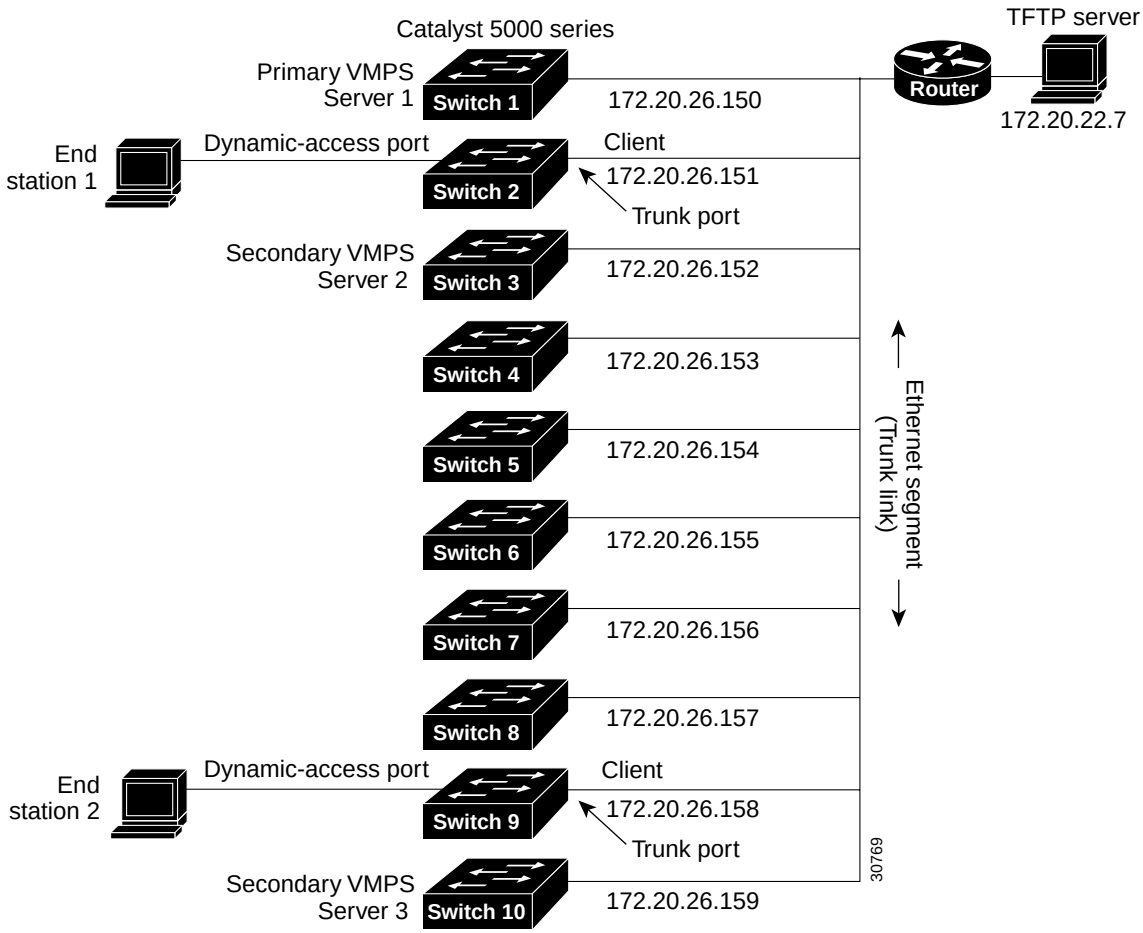
To re-enable a disabled dynamic port, enter the **no shutdown** interface configuration command.

VMPS Configuration Example

Figure 15-5 shows a network with a VMPS server switch and VMPS client switches with dynamic ports. In this example, these assumptions apply:

- The VMPS server and the VMPS client are separate switches.
- The Catalyst 5000 series Switch 1 is the primary VMPS server.
- The Catalyst 5000 series Switch 3 and Switch 10 are secondary VMPS servers.
- The end stations are connected to these clients:
  - Catalyst 2950 Switch 2
  - Catalyst 3500 XL Switch 9
- The database configuration file is stored on the TFTP server with the IP address 172.20.22.7.

Figure 15-5 Dynamic Port VLAN Membership Configuration



CHAPTER 16

Configuring VTP

This chapter describes how to use the VLAN Trunking Protocol (VTP) and the VLAN database for managing VLANs on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

The chapter includes these sections:

- Understanding VTP, page 16-1
- Configuring VTP, page 16-6
- Monitoring VTP, page 16-15

Understanding VTP

VTP is a Layer 2 messaging protocol that maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP minimizes misconfigurations and configuration inconsistencies that can cause several problems, such as duplicate VLAN names, incorrect VLAN-type specifications, and security violations.

Before you create VLANs, you must decide whether to use VTP in your network. Using VTP, you can make configuration changes centrally on one or more switches and have those changes automatically communicated to all the other switches in the network. Without VTP, you cannot send information about VLANs to other switches. VTP configuration information is saved in the VTP VLAN database.

VTP only learns about normal-range VLANs (VLAN IDs 1 to 1005). Extended-range VLANs (VLAN IDs greater than 1005) are not supported by VTP or stored in the VTP VLAN database. Extended-range VLANs are only supported when the enhanced software image (EI) is installed.

This section contains information about these VTP parameters:

- The VTP Domain, page 16-2
- VTP Modes, page 16-3
- VTP Advertisements, page 16-3
- VTP Version 2, page 16-4
- VTP Pruning, page 16-4

The VTP Domain

A VTP domain (also called a VLAN management domain) consists of one switch or several interconnected switches under the same administrative responsibility sharing the same VTP domain name. A switch can be in only one VTP domain.You make global VLAN configuration changes for the domain by using the command-line interface (CLI), Cluster Management Suite (CMS) software, or Simple Network Management Protocol (SNMP).

By default, the switch is in VTP no-management-domain state until it receives an advertisement for a domain over a trunk link (a link that carries the traffic of multiple VLANs) or until you configure a domain name. Until the management domain name is specified or learned, you cannot create or modify VLANs on a VTP server, and VLAN information is not propagated over the network.

If the switch receives a VTP advertisement over a trunk link, it inherits the management domain name and the VTP configuration revision number. The switch then ignores advertisements with a different domain name or an earlier configuration revision number.

Caution Before adding a VTP client switch to a VTP domain, always verify that its VTP configuration revision number is *lower* than the configuration revision number of the other switches in the VTP domain. Switches in a VTP domain always use the VLAN configuration of the switch with the highest VTP configuration revision number. If you add a switch that has a revision number higher than the revision number in the VTP domain, it can erase all VLAN information from the VTP server and VTP domain. See the "Adding a VTP Client Switch to a VTP Domain" section on page 16-14 for the procedure for verifying and resetting the VTP configuration revision number.

When you make a change to the VLAN configuration on a VTP server, the change is propagated to all switches in the VTP domain. VTP advertisements are sent over all IEEE 802.1Q trunk connections. VTP maps VLANs dynamically across multiple LAN types with unique names and internal index associates. Mapping eliminates excessive device administration required from network administrators.

If you configure a switch for VTP transparent mode, you can create and modify VLANs, but the changes are not sent to other switches in the domain, and they affect only the individual switch. However, configuration changes made when the switch is in this mode are saved in the switch running configuration and can be saved to the switch startup configuration file.

For domain name and password configuration guidelines, see the "VTP Configuration Guidelines" section on page 16-8.

VTP Modes

You can configure a supported switch to be in one of the VTP modes listed in Table 16-1.

Table 16-1 VTP Modes

VTP Mode	Description
VTP server	In VTP server mode, you can create, modify, and delete VLANs and specify other configuration parameters (such as the VTP version) for the entire VTP domain. VTP servers advertise their VLAN configurations to other switches in the same VTP domain and synchronize their VLAN configurations with other switches based on advertisements received over trunk links. In VTP server mode, VLAN configurations are saved in nonvolatile RAM (NVRAM). VTP server is the default mode.
VTP client	A VTP client behaves like a VTP server, but you cannot create, change, or delete VLANs on a VTP client. In VTP client mode, VLAN configurations are not saved in NVRAM.
VTP transparent	VTP transparent switches do not participate in VTP. A VTP transparent switch does not advertise its VLAN configuration and does not synchronize its VLAN configuration based on received advertisements. However, in VTP version 2, transparent switches do forward VTP advertisements that they receive from other switches from their trunk interfaces. You can create, modify, and delete VLANs on a switch in VTP transparent mode. The switch must be in VTP transparent mode when you create extended-range VLANs. See the "Configuring Extended-Range VLANs" section on page 15-12. When the switch is in VTP transparent mode, the VTP and VLAN configurations are saved in NVRAM, but they are not advertised to other switches. In this mode, VTP mode and domain name are saved in the switch running configuration and you can save this information in the switch startup configuration file by entering the **copy running-config startup-config** privileged EXEC command.

When the network is configured with more than the maximum 250 VLANs, the switch automatically changes from VTP server or client mode to VTP transparent mode. The switch then operates with the VLAN configuration that preceded the one that sent it into transparent mode.

VTP Advertisements

Each switch in the VTP domain sends periodic global configuration advertisements from each trunk port to a reserved multicast address. Neighboring switches receive these advertisements and update their VTP and VLAN configurations as necessary.

Note Because trunk ports send and receive VTP advertisements, you must ensure that at least one trunk port is configured on the switch and that this trunk port is connected to the trunk port of a second switch. Otherwise, the switch cannot receive any VTP advertisements. For more information on trunk ports, see the "Configuring VLAN Trunks" section on page 15-15.

VTP advertisements distribute this global domain information:

- VTP domain name
- VTP configuration revision number
- Update identity and update timestamp

- MD5 digest VLAN configuration, including maximum transmission unit (MTU) size for each VLAN.
- Frame format

VTP advertisements distribute this VLAN information for each configured VLAN:

- VLAN IDs
- VLAN name
- VLAN type
- VLAN state
- Additional VLAN configuration information specific to the VLAN type

VTP Version 2

If you use VTP in your network, you must decide whether to use version 1 or version 2. By default, VTP operates in version 1.

VTP version 2 supports these features not supported in version 1:

- Token Ring support—VTP version 2 supports Token Ring Bridge Relay Function (TrBRF) and Token Ring Concentrator Relay Function (TrCRF) VLANs. For more information about Token Ring VLANs, see the "Configuring Normal-Range VLANs" section on page 15-4.
- Unrecognized Type-Length-Value (TLV) support—A VTP server or client propagates configuration changes to its other trunks, even for TLVs it is not able to parse. The unrecognized TLV is saved in NVRAM when the switch is operating in VTP server mode.
- Version-Dependent Transparent Mode—In VTP version 1, a VTP transparent switch inspects VTP messages for the domain name and version and forwards a message only if the version and domain name match. Because VTP version 2 supports only one domain, it forwards VTP messages in transparent mode without inspecting the version and domain name.
- Consistency Checks—In VTP version 2, VLAN consistency checks (such as VLAN names and values) are performed only when you enter new information through the CLI, the Cluster Management Software (CMS), or SNMP. Consistency checks are not performed when new information is obtained from a VTP message or when information is read from NVRAM. If the MD5 digest on a received VTP message is correct, its information is accepted.

VTP Pruning

VTP pruning increases network available bandwidth by restricting flooded traffic to those trunk links that the traffic must use to reach the destination devices. Without VTP pruning, a switch floods broadcast, multicast, and unknown unicast traffic across all trunk links within a VTP domain even though receiving switches might discard them. VTP pruning is disabled by default.

VTP pruning blocks unneeded flooded traffic to VLANs on trunk ports that are included in the pruning-eligible list. Only VLANs included in the pruning-eligible list can be pruned. By default, VLANs 2 through 1001 are pruning eligible switch trunk ports. If the VLANs are configured as pruning-ineligible, the flooding continues. VTP pruning is supported with VTP version 1 and version 2.

Figure 16-1 shows a switched network without VTP pruning enabled. Port 1 on Switch 1 and Port 2 on Switch 4 are assigned to the Red VLAN. If a broadcast is sent from the host connected to Switch 1, Switch 1 floods the broadcast and every switch in the network receives it, even though Switches 3, 5, and 6 have no ports in the Red VLAN.

Figure 16-1 Flooding Traffic without VTP Pruning

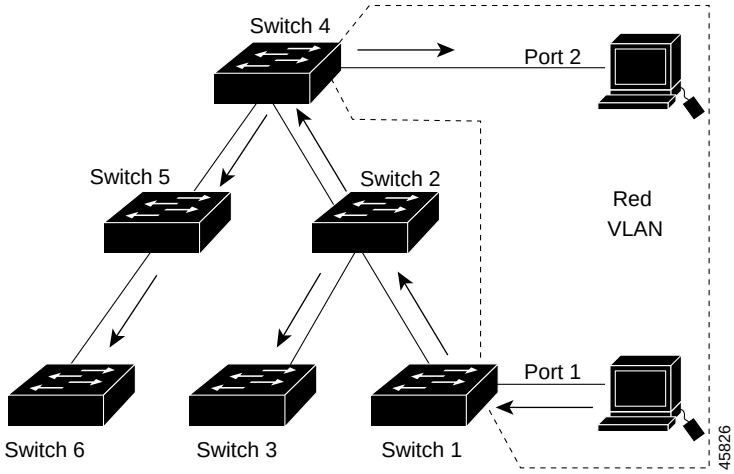
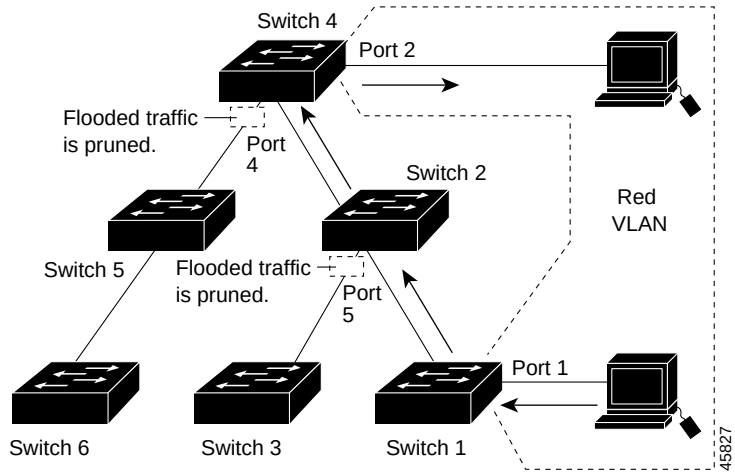


Figure 16-2 shows a switched network with VTP pruning enabled. The broadcast traffic from Switch 1 is not forwarded to Switches 3, 5, and 6 because traffic for the Red VLAN has been pruned on the links shown (Port 5 on Switch 2 and Port 4 on Switch 4).

Figure 16-2 Optimized Flooded Traffic with VTP Pruning



Enabling VTP pruning on a VTP server enables pruning for the entire management domain. Making VLANs pruning-eligible or pruning-ineligible affects pruning eligibility for those VLANs on that device only (not on all switches in the VTP domain). See the "Enabling VTP Pruning" section on page 16-14. VTP pruning takes effect several seconds after you enable it. VTP pruning does not prune traffic from VLANs that are pruning-ineligible. VLAN 1 and VLANs 1002 to 1005 are always pruning-ineligible; traffic from these VLANs cannot be pruned. Extended-range VLANs (VLAN IDs higher than 1005) are also pruning-ineligible.

VTP pruning is not designed to function in VTP transparent mode. If one or more switches in the network are in VTP transparent mode, you should do one of these:

- Turn off VTP pruning in the entire network.
- Turn off VTP pruning by making all VLANs on the trunk of the switch upstream to the VTP transparent switch pruning ineligible.

To configure VTP pruning on an interface, use the **switchport trunk pruning vlan** interface configuration command (see the "Changing the Pruning-Eligible List" section on page 15-20). VTP pruning operates when an interface is trunking. You can set VLAN pruning-eligibility, whether or not VTP pruning is enabled for the VTP domain, whether or not any given VLAN exists, and whether or not the interface is currently trunking.

Configuring VTP

This section includes guidelines and procedures for configuring VTP. These sections are included:

- Default VTP Configuration, page 16-6
- VTP Configuration Options, page 16-7
- VTP Configuration Guidelines, page 16-8
- Configuring a VTP Server, page 16-9
- Configuring a VTP Client, page 16-11
- Disabling VTP (VTP Transparent Mode), page 16-12
- Enabling VTP Version 2, page 16-13
- Enabling VTP Pruning, page 16-14
- Adding a VTP Client Switch to a VTP Domain, page 16-14

Default VTP Configuration

Table 16-2 shows the default VTP configuration.

Table 16-2 Default VTP Configuration

Feature	Default Setting
VTP domain name	Null.
VTP mode	Server.
VTP version 2 enable state	Version 2 is disabled.
VTP password	None.
VTP pruning	Disabled.

VTP Configuration Options

You can configure VTP by using these configuration modes.

- VTP Configuration in Global Configuration Mode, page 16-7
- VTP Configuration in VLAN Configuration Mode, page 16-7

  You access VLAN configuration mode by entering the **vlan database** privileged EXEC command.

For detailed information about **vtp** commands, refer to the command reference for this release.

VTP Configuration in Global Configuration Mode

You can use the **vtp** global configuration command to set the VTP password, the version, the VTP file name, the interface providing updated VTP information, the domain name, and the mode, and to disable or enable pruning. For more information about available keywords, refer to the command descriptions in the command reference for this release. The VTP information is saved in the VTP VLAN database. When VTP mode is transparent, the VTP domain name and mode are also saved in the switch running configuration file, and you can save it in the switch startup configuration file by entering the **copy running-config startup-config** privileged EXEC command. You must use this command if you want to save VTP mode as transparent, even if the switch resets.

When you save VTP information in the switch startup configuration file and reboot the switch, the switch configuration is determined as follows:

- If the VTP mode is transparent in the startup configuration and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.
- If the VTP mode or domain name in the startup configuration do not match the VLAN database, the domain name and VTP mode and configuration for the first 1005 VLANs use the VLAN database information.
- If the switch is running IOS Release 12.1(9)EA1 or later and you use an older configuration file to boot up the switch, the configuration file does not contain VTP or VLAN information, and the switch uses the VLAN database configurations.
- If the switch is running an IOS release earlier than 12.1(9)EA1 on the switch and you use a configuration file from IOS Release 12.1(9)EA1 or later to boot up the switch, the image on the switch does not recognize VLAN and VTP configurations in the configuration file, so the switch uses the VLAN database configuration.

VTP Configuration in VLAN Configuration Mode

You can configure all VTP parameters in VLAN configuration mode, which you access by entering the **vlan database** privileged EXEC command. For more information about available keywords, refer to the **vtp** VLAN configuration command description in the command reference for this release. When you enter the **exit** command in VLAN configuration mode, it applies all the commands that you entered and updates the VLAN database. VTP messages are sent to other switches in the VTP domain, and the privileged EXEC mode prompt appears.

If VTP mode is transparent, the domain name and the mode (transparent) are saved in the switch running configuration, and you can save this information in the switch startup configuration file by entering the **copy running-config startup-config** privileged EXEC command.

VTP Configuration Guidelines

These sections describe guidelines you should follow when implementing VTP in your network.

Domain Names

When configuring VTP for the first time, you must always assign a domain name. You must configure all switches in the VTP domain with the same domain name. Switches in VTP transparent mode do not exchange VTP messages with other switches, and you do not need to configure a VTP domain name for them.

Note If NVRAM and DRAM storage is sufficient, all switches in a VTP domain should be in VTP server mode.

Caution Do not configure a VTP domain if all switches are operating in VTP client mode. If you configure the domain, it is impossible to make changes to the VLAN configuration of that domain. Make sure that you configure at least one switch in the VTP domain for VTP server mode.

Passwords

You can configure a password for the VTP domain, but it is not required. If you do configure a domain password, all domain switches must share the same password and you must configure the password on each switch in the management domain. Switches without a password or with the wrong password reject VTP advertisements.

If you configure a VTP password for a domain, a switch that is booted without a VTP configuration does not accept VTP advertisements until you configure it with the correct password. After the configuration, the switch accepts the next VTP advertisement that uses the same password and domain name in the advertisement.

If you are adding a new switch to an existing network with VTP capability, the new switch learns the domain name only after the applicable password has been configured on it.

Caution When you configure a VTP domain password, the management domain does not function properly if you do not assign a management domain password to each switch in the domain.

Upgrading from Previous Software Releases

When you upgrade from an IOS software version that supports VLANs but does not support VTP, such as Release 12.0(5.1)WC, to a version that does support VTP, ports that belong to a VLAN retain their VLAN membership, and VTP enters transparent mode. The domain name becomes UPGRADE, and VTP does not propagate the VLAN configuration to other switches.

If you want the switch to propagate VLAN configuration information to other switches and to learn the VLANs enabled on the network, you must configure the switch with the correct domain name and domain password and change the VTP mode to VTP server.

VTP Version

Follow these guidelines when deciding which VTP version to implement:

- All switches in a VTP domain must run the same VTP version.
- A VTP version 2-capable switch can operate in the same VTP domain as a switch running VTP version 1 if version 2 is disabled on the version 2-capable switch (version 2 is disabled by default).
- Do not enable VTP version 2 on a switch unless all of the switches in the same VTP domain are version-2-capable. When you enable version 2 on a switch, all of the version-2-capable switches in the domain enable version 2. If there is a version 1-only switch, it does not exchange VTP information with switches with version 2 enabled.
- If there are TrBRF and TrCRF Token Ring networks in your environment, you must enable VTP version 2 for Token Ring VLAN switching to function properly. To run Token Ring and Token Ring-Net, disable VTP version 2.

Configuration Requirements

When you configure VTP, you must configure a trunk port so that the switch can send and receive VTP advertisements. For more information, see the "Configuring VLAN Trunks" section on page 15-15.

If you are configuring VTP on a cluster member switch to a VLAN, use the **rcommand** privileged EXEC command to log into the member switch. For more information about the command, refer to the command reference for this release.

If you are configuring extended-range VLANs on the switch, the switch must be in VTP transparent mode.

Configuring a VTP Server

When a switch is in VTP server mode, you can change the VLAN configuration and have it propagated throughout the network.

Note If extended-range VLANs are configured on the switch, you cannot change VTP mode to server. You receive an error message, and the configuration is not allowed.

Beginning in privileged EXEC mode, follow these steps to configure the switch as a VTP server:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vtp mode server**	Configure the switch for VTP server mode (the default).
Step 3	**vtp domain** *domain-name*	Configure the VTP administrative-domain name. The name can be from 1 to 32 characters. All switches operating in VTP server or client mode under the same administrative responsibility must be configured with the same domain name.

	Command	Purpose
Step 4	**vtp password** *password*	(Optional) Set the password for the VTP domain. The password can be from 8 to 64 characters. If you configure a VTP password, the VTP domain does not function properly if you do not assign the same password to each switch in the domain.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show vtp status**	Verify your entries in the *VTP Operating Mode* and the *VTP Domain Name* fields of the display.

When you configure a domain name, it cannot be removed; you can only reassign a switch to a different domain.

To return the switch to a no-password state, use the **no vtp password** global configuration command.

This example shows how to use global configuration mode to configure the switch as a VTP server with the domain name *eng_group* and the password *mypassword*:

```
Switch# config terminal
Switch(config)# vtp mode server
Switch(config)# vtp domain eng_group
Switch(config)# vtp password mypassword
Switch(config)# end
```

You can also use VLAN configuration mode to configure VTP parameters. Beginning in privileged EXEC mode, follow these steps to use VLAN configuration mode to configure the switch as a VTP server:

	Command	Purpose
Step 1	**vlan database**	Enter VLAN configuration mode.
Step 2	**vtp server**	Configure the switch for VTP server mode (the default).
Step 3	**vtp domain** *domain-name*	Configure a VTP administrative-domain name. The name can be from 1 to 32 characters. All switches operating in VTP server or client mode under the same administrative responsibility must be configured with the same domain name.
Step 4	**vtp password** *password*	(Optional) Set a password for the VTP domain. The password can be from 8 to 64 characters. If you configure a VTP password, the VTP domain does not function properly if you do not assign the same password to each switch in the domain.
Step 5	**exit**	Update the VLAN database, propagate it throughout the administrative domain, and return to privileged EXEC mode.
Step 6	**show vtp status**	Verify your entries in the *VTP Operating Mode* and the *VTP Domain Name* fields of the display.

When you configure a domain name, it cannot be removed; you can only reassign a switch to a different domain.

To return the switch to a no-password state, use the **no vtp password** VLAN configuration command.

This example shows how to use VLAN configuration mode to configure the switch as a VTP server with the domain name *eng_group* and the password *mypassword*:

```
Switch# vlan database
Switch(vlan)# vtp server
Switch(vlan)# vtp domain eng_group
Switch(vlan)# vtp password mypassword
Switch(vlan)# exit
APPLY completed.
Exiting....
```

Configuring a VTP Client

When a switch is in VTP client mode, you cannot change its VLAN configuration. The client switch receives VTP updates from a VTP server in the VTP domain and then modifies its configuration accordingly.

Note If extended-range VLANs are configured on the switch, you cannot change VTP mode to client. You receive an error message, and the configuration is not allowed.

Caution If all switches are operating in VTP client mode, do not configure a VTP domain name. If you do, it is impossible to make changes to the VLAN configuration of that domain. Therefore, make sure you configure at least one switch as a VTP server.

Beginning in privileged EXEC mode, follow these steps to configure the switch as a VTP client:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vtp mode client**	Configure the switch for VTP client mode. The default setting is VTP server.
Step 3	**vtp domain** *domain-name*	(Optional) Enter the VTP administrative-domain name. The name can be from 1 to 32 characters. This should be the same domain name as the VTP server. All switches operating in VTP server or client mode under the same administrative responsibility must be configured with the same domain name.
Step 4	**vtp password** *password*	(Optional) Enter the password for the VTP domain.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show vtp status**	Verify your entries in the *VTP Operating Mode* and the *VTP Domain Name* fields of the display.

Use the **no vtp mode** global configuration command to return the switch to VTP server mode. To return the switch to a no-password state, use the **no vtp password** global configuration command. When you configure a domain name, it cannot be removed; you can only reassign a switch to a different domain.

Note You can also configure a VTP client by using the **vlan database** privileged EXEC command to enter VLAN configuration mode and entering the **vtp client** command, similar to the second procedure under "Configuring a VTP Server" section on page 16-9. Use the **no vtp client** VLAN configuration command to return the switch to VTP server mode or the **no vtp password** VLAN configuration command to return the switch to a no-password state. When you configure a domain name, it cannot be removed; you can only reassign a switch to a different domain.

Disabling VTP (VTP Transparent Mode)

When you configure the switch for VTP transparent mode, you disable VTP on the switch. The switch does not send VTP updates and does not act on VTP updates received from other switches. However, a VTP transparent switch running VTP version 2 does forward received VTP advertisements on all of its trunk links.

Note Before you create extended-range VLANs (VLAN IDs 1006 to 4094), you must set VTP mode to transparent by using the **vtp mode transparent** global configuration command. Save this configuration to the startup configuration so that the switch boots up in VTP transparent mode. Otherwise, you lose the extended-range VLAN configuration if the switch resets and boots up in VTP server mode (the default).

Beginning in privileged EXEC mode, follow these steps to configure VTP transparent mode and save the VTP configuration in the switch startup configuration file:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vtp mode transparent**	Configure the switch for VTP transparent mode (disable VTP).
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show vtp status**	Verify your entries in the *VTP Operating Mode* and the *VTP Domain Name* fields of the display.
Step 5	**copy running-config startup-config**	(Optional) Save the configuration in the startup configuration file. **Note** Only VTP mode and domain name are saved in the switch running configuration and can be copied to the startup configuration file.

To return the switch to VTP server mode, use the **no vtp mode** global configuration command.

Note If extended-range VLANs are configured on the switch, you cannot change VTP mode to server. You receive an error message, and the configuration is not allowed.

Note You can also configure VTP transparent mode by using the **vlan database** privileged EXEC command to enter VLAN configuration mode and by entering the **vtp transparent** command, similar to the second procedure under the "Configuring a VTP Server" section on page 16-9. Use the **no vtp transparent** VLAN configuration command to return the switch to VTP server mode. If extended-range VLANs are configured on the switch, you cannot change VTP mode to server. You receive an error message, and the configuration is not allowed.

Enabling VTP Version 2

VTP version 2 is disabled by default on VTP version 2-capable switches. When you enable VTP version 2 on a switch, every VTP version 2-capable switch in the VTP domain enables version 2. You can only configure the version on switches in VTP server or transparent mode.

Caution VTP version 1 and VTP version 2 are not interoperable on switches in the same VTP domain. Every switch in the VTP domain must use the same VTP version. Do not enable VTP version 2 unless every switch in the VTP domain supports version 2.

Note In TrCRF and TrBRF Token ring environments, you must enable VTP version 2 for Token Ring VLAN switching to function properly. For Token Ring and Token Ring-Net media, VTP version 2 must be disabled.

For more information on VTP version configuration guidelines, see the "VTP Version" section on page 16-9.

Beginning in privileged EXEC mode, follow these steps to enable VTP version 2:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vtp version 2**	Enable VTP version 2 on the switch. VTP version 2 is disabled by default on VTP version 2-capable switches.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show vtp status**	Verify that VTP version 2 is enabled in the *VTP V2 Mode* field of the display.

To disable VTP version 2, use the **no vtp version** global configuration command**.**

Note You can also enable VTP version 2 by using the **vlan database** privileged EXEC command to enter VLAN configuration mode and entering the **vtp v2-mode** VLAN configuration command. To disable VTP version 2, use the **no vtp v2-mode** VLAN configuration command.

Enabling VTP Pruning

Pruning increases available bandwidth by restricting flooded traffic to those trunk links that the traffic must use to access the destination devices. You can only enable VTP pruning on a switch in VTP server mode.

Beginning in privileged EXEC mode, follow these steps to enable VTP pruning in the VTP domain:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**vtp pruning**	Enable pruning in the VTP administrative domain. By default, pruning is disabled. You need to enable pruning on only one switch in VTP server mode.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show vtp status**	Verify your entries in the *VTP Pruning Mode* field of the display.

To disable VTP pruning, use the **no vtp pruning** global configuration command.

Note You can also enable VTP pruning by using the **vlan database** privileged EXEC command to enter VLAN configuration mode and entering the **vtp pruning** VLAN configuration command. To disable VTP pruning, use the **no vtp pruning** VLAN configuration command.

Pruning is supported with VTP version 1 and version 2. If you enable pruning on the VTP server, it is enabled for the entire VTP domain.

Only VLANs included in the pruning-eligible list can be pruned. By default, VLANs 2 through 1001 are pruning eligible on trunk ports. Reserved VLANs and extended-range VLANs cannot be pruned. To change the pruning-eligible VLANs, see the "Changing the Pruning-Eligible List" section on page 15-20.

Adding a VTP Client Switch to a VTP Domain

Before adding a VTP client to a VTP domain, always verify that its VTP configuration revision number is *lower* than the configuration revision number of the other switches in the VTP domain. Switches in a VTP domain always use the VLAN configuration of the switch with the highest VTP configuration revision number. If you add a switch that has a revision number higher than the revision number in the VTP domain, it can erase all VLAN information from the VTP server and VTP domain.

Beginning in privileged EXEC mode, follow these steps to verify and reset the VTP configuration revision number on a switch *before* adding it to a VTP domain:

	Command	Purpose
Step 1	**show vtp status**	Check the VTP configuration revision number. If the number is 0, add the switch to the VTP domain. If the number is greater than 0, follow these steps: **a.** Write down the domain name. **b.** Write down the configuration revision number. **c.** Continue with the next steps to reset the configuration revision number on the switch.
Step 2	**configure terminal**	Enter global configuration mode.
Step 3	**vtp domain** *domain-name*	Change the domain name from the original one displayed in Step 1 to a new name.
Step 4	**end**	The VLAN information on the switch is updated and the configuration revision number is reset to 0. You return to privileged EXEC mode.
Step 5	**show vtp status**	Verify that the configuration revision number has been reset to 0.
Step 6	**configure terminal**	Enter global configuration mode.
Step 7	**vtp domain** *domain-name*	Enter the original domain name on the switch.
Step 8	**end**	The VLAN information on the switch is updated, and you return to privileged EXEC mode.
Step 9	**show vtp status**	(Optional) Verify that the domain name is the same as in Step 1 and that the configuration revision number is 0.

You can also change the VTP domain name by entering the **vlan database** privileged EXEC command to enter VLAN configuration mode and by entering the **vtp domain** *domain-name* command. In this mode, you must enter the **exit** command to update VLAN information and return to privileged EXEC mode.

After resetting the configuration revision number, add the switch to the VTP domain.

Note You can use the **vtp mode transparent** global configuration command or the **vtp transparent** VLAN configuration command to disable VTP on the switch, and then change its VLAN information without affecting the other switches in the VTP domain.

Monitoring VTP

You monitor VTP by displaying VTP configuration information: the domain name, the current VTP revision, and the number of VLANs. You can also display statistics about the advertisements sent and received by the switch.

Table 16-3 shows the privileged EXEC commands for monitoring VTP activity.

Table 16-3 VTP Monitoring Commands

Command	Purpose
show vtp status	Display the VTP switch configuration information.
show vtp counters	Display counters about VTP messages that have been sent and received.

This is an example of output from the **show vtp status** privileged EXEC command:

```
Switch# show vtp status
VTP Version                     : 2
Configuration Revision          : 25
Maximum VLANs supported locally : 250
Number of existing VLANs        : 69
VTP Operating Mode              : Server
VTP Domain Name                 : test
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0x59 0xBA 0x92 0xA4 0x74 0xD5 0x42 0x29
Configuration last modified by 0.0.0.0 at 3-1-93 00:18:42
Local updater ID is 10.1.1.59 on interface Vl1 (lowest numbered VLAN interface found)
```

This is an example of output from the **show vtp counters** privileged EXEC command:

```
Switch# show vtp counters
VTP statistics:
Summary advertisements received    : 20
Subset advertisements received     : 0
Request advertisements received    : 0
Summary advertisements transmitted : 11
Subset advertisements transmitted  : 0
Request advertisements transmitted : 0
Number of config revision errors   : 0
Number of config digest errors     : 0
Number of V1 summary errors        : 0

VTP pruning statistics:

Trunk            Join Transmitted Join Received    Summary advts received from
                                                   non-pruning-capable device
---------------- ---------------- ---------------- ---------------------------
```

CHAPTER 17

Configuring Voice VLAN

This chapter describes how to configure the voice VLAN feature on your Catalyst 2950 or Catalyst 2955 switch. Voice VLAN is referred to as an *auxiliary VLAN* in the Catalyst 6000 family switch documentation.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding Voice VLAN, page 17-1
- Configuring Voice VLAN, page 17-2
- Displaying Voice VLAN, page 17-6

Understanding Voice VLAN

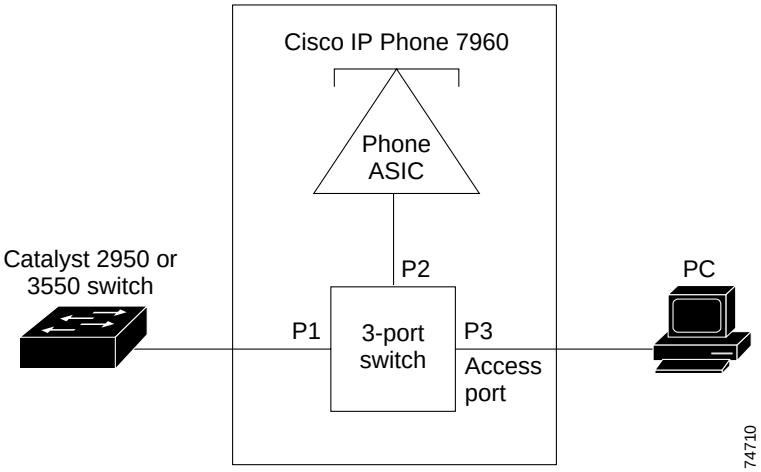
The voice VLAN feature enables access ports to carry IP voice traffic from an IP phone. The switch can connect to a Cisco 7960 IP Phone and carry IP voice traffic. Because the sound quality of an IP phone call can deteriorate if the data is unevenly sent, the switch supports quality of service (QoS) based on IEEE 802.1P class of service (CoS). QoS uses classification and scheduling to send network traffic from the switch in a predictable manner. For more information on QoS, see Chapter 27, "Configuring QoS." The Cisco 7960 IP Phone is a configurable device, and you can configure it to forward traffic with an 802.1P priority. You can configure the switch to trust or override the traffic priority assigned by an IP Phone.

The Cisco 7960 IP Phone contains an integrated three-port 10/100 switch as shown in Figure 17-1. The ports provide dedicated connections to these devices:

- Port 1 connects to the switch or other voice-over-IP (VoIP) device.
- Port 2 is an internal 10/100 interface that carries the IP phone traffic.
- Port 3 (access port) connects to a PC or other device.

Figure 17-1 shows one way to connect a Cisco 7960 IP Phone.

Figure 17-1 Cisco 7960 IP Phone Connected to a Switch



When the IP Phone connects to the switch, the access port (PC-to-telehone jack) of the IP phone can connect to a PC. Packets to and from the PC and to or from the IP phone share the same physical link to the switch and the same switch port. For deployment examples that use voice VLANs, refer to the "Network Configuration Examples" section on page 1-8.

Configuring Voice VLAN

This section describes how to configure voice VLAN on access ports. It contains this configuration information:

- Default Voice VLAN Configuration, page 17-2
- Voice VLAN Configuration Guidelines, page 17-3
- Configuring a Port to Connect to a Cisco 7960 IP Phone, page 17-3

Default Voice VLAN Configuration

The voice VLAN feature is disabled by default.

When the voice VLAN feature is enabled, all untagged traffic is sent according to the default CoS priority of the port.

The default CoS value is 0 for incoming traffic.

The CoS value is not trusted for 802.1P or 802.1Q tagged traffic.

The IP Phone overrides the priority of all incoming traffic (tagged and untagged) and sets the CoS value to 0.

Note In software releases earlier than Release 12.1(13)EA1, the CoS value is trusted for all 802.1P or 802.1Q tagged traffic, and the IP Phone does not override the priority of the incoming traffic.

Voice VLAN Configuration Guidelines

These are the voice VLAN configuration guidelines:

- You should configure voice VLAN on switch access ports.
- The Port Fast feature is automatically enabled when voice VLAN is configured. When you disable voice VLAN, the Port Fast feature is not automatically disabled.
- When you enable port security on an interface that is also configured with a voice VLAN, you must set the maximum allowed secure addresses on the port to at least two secure addresses. If any type of port security is enabled on the access VLAN, dynamic port security is automatically enabled on the voice VLAN. You cannot configure port security on a per-VLAN basis.
- You cannot configure static secure or sticky secure MAC addresses on a voice VLAN.
- Voice VLAN ports can also be these port types:
  - Dynamic access port. See the "Configuring Dynamic Access Ports on VMPS Clients" section on page 15-29 for more information.
  - Secure port. See the "Configuring Port Security" section on page 19-4 for more information.
  - 802.1X authenticated port. See the "Voice VLAN Ports" section on page 10-5 for more information.
  - Protected port. See the "Configuring Protected Ports" section on page 19-3 for more information.

Configuring a Port to Connect to a Cisco 7960 IP Phone

Because a Cisco 7960 IP Phone also supports a connection to a PC or other device, a port connecting the switch to a Cisco 7960 IP Phone can carry mixed traffic.

You can configure the port to carry voice traffic in one of these ways:

- Configuring Ports to Carry Voice Traffic in 802.1Q Frames, page 17-4
- Configuring Ports to Carry Voice Traffic in 802.1P Priority-Tagged Frames, page 17-4

You can configure the IP phone to carry data traffic in one of these ways:

- Overriding the CoS Priority of Incoming Data Frames, page 17-5
- Configuring the IP Phone to Trust the CoS Priority of Incoming Data Frames, page 17-6

Configuring Ports to Carry Voice Traffic in 802.1Q Frames

Beginning in privileged EXEC mode, follow these steps to configure a port to carry voice traffic in 802.1Q frames for a specific VLAN:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the interface connected to the IP phone, and enter interface configuration mode.
Step 3	**switchport voice vlan** *vlan-id*	Instruct the Cisco IP Phone to forward all voice traffic through the specified VLAN. By default, the Cisco IP Phone forwards the voice traffic with an 802.1Q priority of 5. Valid VLAN IDs are from 1 to 4094 when the enhanced software image (EI) is installed and 1 to 1001 when the standard software image is installed.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your voice VLAN entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove voice VLAN, use the **no switchport voice vlan** interface configuration command or the **switchport voice vlan none** interface configuration command.

Configuring Ports to Carry Voice Traffic in 802.1P Priority-Tagged Frames

Beginning in privileged EXEC mode, follow these steps to configure a port to instruct the IP phone to give voice traffic a higher priority and to forward all traffic through the native VLAN.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the interface connected to the IP phone, and enter interface configuration mode.
Step 3	**switchport voice vlan dot1p**	Instruct the switch port to use 802.1P priority tagging for voice traffic and to use the default native VLAN (VLAN 0) to carry all traffic. By default, the Cisco IP phone forwards the voice traffic with an 802.1P priority of 5.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your voice VLAN entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the port to its default setting, use the **no switchport voice vlan** interface configuration command.

Overriding the CoS Priority of Incoming Data Frames

You can connect a PC or other data device to a Cisco 7960 IP Phone port. The PC can generate packets with an assigned CoS value. You can configure the switch to override the priority of frames arriving on the IP phone port from connected devices.

Beginning in privileged EXEC mode, follow these steps to override the CoS priority received from the nonvoice port on the Cisco 7960 IP Phone:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface connected to the IP phone.
Step 3	**switchport priority extend cos** *value*	Set the IP phone access port to override the priority received from the PC or the attached device. The CoS value is a number from 0 to 7. Seven is the highest priority. The default is 0.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no switchport priority extend** interface configuration command or the **switchport priority extend cos 0** interface configuration command to return the port to its default setting.

Configuring the IP Phone to Trust the CoS Priority of Incoming Data Frames

You can connect a PC or other data device to a Cisco 7960 IP Phone port. The PC can generate packets with an assigned CoS value. You can configure the switch to trust the priority of frames arriving on the IP phone port from connected devices.

Beginning in privileged EXEC mode, follow these steps to trust the CoS priority received from the nonvoice port on the Cisco 7960 IP Phone:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface connected to the IP phone.
Step 3	**switchport priority extend trust**	Set the IP phone access port to trust the priority received from the PC or the attached device.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the port to its default setting, use the **no switchport priority extend** interface configuration command or the **switchport priority extend cos 0** interface configuration command.

Displaying Voice VLAN

To display voice VLAN for an interface, use the **show interfaces** *interface-id* **switchport** privileged EXEC command.

For detailed information about the fields in the display, refer to the command reference for this release.

CHAPTER 18

Configuring IGMP Snooping and MVR

This chapter describes how to configure Internet Group Management Protocol (IGMP) snooping on your Catalyst 2950 or Catalyst 2955 switch, including an application of local IGMP snooping, Multicast VLAN Registration (MVR). It also includes procedures for controlling multicast group membership by using IGMP filtering.

Note For complete syntax and usage information for the commands used in this chapter, refer to the switch command reference for this release and the *Cisco IOS Release Network Protocols Command Reference, Part 1, for Release 12.1*.

This chapter consists of these sections:

- Understanding IGMP Snooping, page 18-1
- Configuring IGMP Snooping, page 18-5
- Displaying IGMP Snooping Information, page 18-10
- Understanding Multicast VLAN Registration, page 18-13
- Configuring MVR, page 18-15
- Displaying MVR Information, page 18-19
- Configuring IGMP Filtering, page 18-20
- Displaying IGMP Filtering Configuration, page 18-24

Note For MAC addresses that map to IP multicast groups, you can either manage them through features such as IGMP snooping and MVR, or you can use static MAC addresses. However, you cannot use both methods simultaneously. Therefore, before using IGMP snooping or MVR, you should remove all statically configured MAC addresses that map to IP multicast groups.

Understanding IGMP Snooping

Layer 2 switches can use IGMP snooping to constrain the flooding ofmulticast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices. As the name implies, IGMP snooping requires the LAN switch to snoop on the IGMP transmissions between the host and the router and to keep track of multicast groups and member ports. When the switch receives an IGMP report from a host for a particular multicast group,

the switch adds the host port number to the forwarding table entry; when it receives an IGMP Leave Group message from a host, it removes the host port from the table entry. It also periodically deletes entries if it does not receive IGMP membership reports from the multicast clients.

Note For more information on IP multicast and IGMP, refer to RFC 1112 and RFC 2236.

The multicast router sends out periodic IGMP general queries to all VLANs. When IGMP snooping is enabled, the switch responds to the router queries with only one join request per MAC multicast group, and the switch creates one entry per VLAN in the Layer 2 forwarding table for each MAC group from which it receives an IGMP join request. All hosts interested in this multicast traffic send join requests and are added to the forwarding table entry.

Layer 2 multicast groups learned through IGMP snooping are dynamic. However, you can statically configure MAC multicast groups by using the **ip igmp snooping vlan static** global configuration command. If you specify group membership for a multicast group address statically, your setting supersedes any automatic manipulation by IGMP snooping. Multicast group membership lists can consist of both user-defined and IGMP snooping-learned settings.

If a port spanning-tree, a port group, or a VLAN ID change occurs, the IGMP snooping-learned multicast groups from this port on the VLAN are deleted.

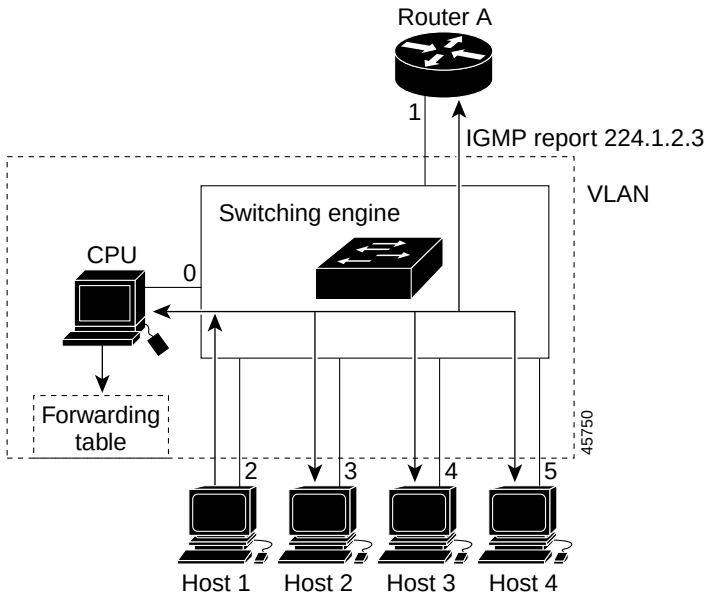
The switches support a maximum of 255 IP multicast groups and support both IGMP version 1 and IGMP version 2.

In the IP multicast-source-only environment, the switch learns the IP multicast group from the IP multicast data stream and only forwards traffic to the multicast router ports. The default learning method is IP multicast-source-only learning.

Joining a Multicast Group

When a host connected to the switch wants to join an IP multicast group, it sends an unsolicited IGMP join message, specifying the IP multicast group to join. Alternatively, when the switch receives a general query from the router, it forwards the query to all ports in the VLAN. Hosts wanting to join the multicast group respond by sending a join message to the switch. The switch CPU creates a multicast forwarding-table entry for the group if it is not already present. The CPU also adds the interface where the join message was received to the forwarding-table entry. The host associated with that interface receives multicast traffic for that multicast group. See Figure 18-1.

Figure 18-1 Initial IGMP Join Message



Router A sends a general query to the switch, which forwards the query to ports 2 through 5, all members of the same VLAN. Host 1 wants to join multicast group 224.1.2.3 and multicasts an IGMP membership report (IGMP join message) to the group with the equivalent MAC destination address of 0x0100.5E01.0203. When the CPU receives the IGMP report multicast by Host 1, the CPU uses the information in the IGMP report to set up a forwarding-table entry, as shown in Table 18-1, that includes the port numbers of Host 1, the router, and the switch internal CPU.

Table 18-1 IGMP Snooping Forwarding Table

Destination Address	Type of Packet	Ports
0100.5exx.xxxx	IGMP	0
0100.5e01.0203	!IGMP	1, 2

Note that the switch hardware can distinguish IGMP information packets from other packets for the multicast group.

- The first entry in the table tells the switching engine to send IGMP packets to only the switch CPU. This prevents the CPU from becoming overloaded with multicast frames.
- The second entry tells the switching engine to send frames addressed to the 0x0100.5E01.0203 multicast MAC address that are not IGMP packets (!IGMP) to the router and to the host that has joined the group.

If another host (for example, Host 4) sends an unsolicited IGMP join message for the same group (Figure 18-2), the CPU receives that message and adds the port number of Host 4 to the forwarding table as shown in Table 18-2. Note that because the forwarding table directs IGMP messages to only the CPU, the message is not flooded to other ports on the switch. Any known multicast traffic is forwarded to the group and not to the CPU. Any unknown multicast traffic is flooded to the VLAN and sent to the CPU until it becomes known.

Figure 18-2 Second Host Joining a Multicast Group

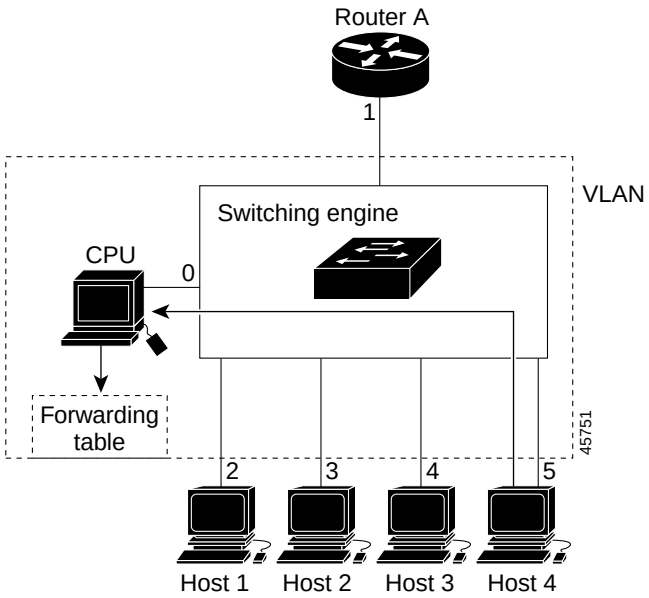


Table 18-2 Updated IGMP Snooping Forwarding Table

Destination Address	Type of Packet	Ports
0100.5exx.xxxx	IGMP	0
0100.5e01.0203	!IGMP	1, 2, 5

Leaving a Multicast Group

The router sends periodic multicast general queries and the switch forwards these queries through all ports in the VLAN. Interested hosts respond to the queries. If at least one host in the VLAN wishes to receive multicast traffic, the router continues forwarding the multicast traffic to the VLAN. The switch forwards multicast group traffic to only those hosts listed in the forwarding table for that Layer 2 multicast group.

When hosts want to leave a multicast group, they can either silently leave, or they can send a leave message. When the switch receives a leave message from a host, it sends out a MAC-based general query to determine if any other devices connected to that interface are interested in traffic for the specific multicast group. The switch then updates the forwarding table for that MAC group so that only those hosts interested in receiving multicast traffic for the group are listed in the forwarding table. If the router receives no reports from a VLAN, it removes the group for the VLAN from its IGMP cache.

Immediate-Leave Processing

The switch uses IGMP snooping Immediate-Leave processing to remove from the forwarding table an interface that sends a leave message without the switch sending MAC-based general queries to the interface. The VLAN interface is pruned from the multicast tree for the multicast group specified in the original leave message. Immediate-Leave processing ensures optimal bandwidth management for all hosts on a switched network, even when multiple multicast groups are simultaneously in use.

Note You should only use the Immediate-Leave processing feature on VLANs where a single host is connected to each port. If Immediate Leave is enabled in VLANs where more than one host is connected to a port, some hosts might be inadvertently dropped. Immediate Leave is supported with only IGMP version 2 hosts.

Configuring IGMP Snooping

IGMP snooping allows switches to examine IGMP packets and make forwarding decisions based on their content.

These sections describe how to configure IGMP snooping:

- Default IGMP Snooping Configuration, page 18-5
- Enabling or Disabling IGMP Snooping, page 18-5
- Setting the Snooping Method, page 18-6
- Configuring a Multicast Router Port, page 18-7
- Configuring a Host Statically to Join a Group, page 18-8
- Enabling IGMP Immediate-Leave Processing, page 18-9
- Disabling IP Multicast-Source-Only Learning, page 18-9

Default IGMP Snooping Configuration

Table 18-3 shows the default IGMP snooping configuration.

Table 18-3 Default IGMP Snooping Configuration

Feature	Default Setting
IGMP snooping	Enabled globally and per VLAN
Multicast routers	None configured
Multicast router learning (snooping) method	PIM-DVMRP
IGMP snooping Immediate Leave	Disabled
Static groups	None configured
IP multicast-source-only learning	Enabled

Enabling or Disabling IGMP Snooping

By default, IGMP snooping is globally enabled on the switch. When globally enabled or disabled, it is also enabled or disabled in all existing VLAN interfaces. IGMP snooping is by default enabled on all VLANs, but can be enabled and disabled on a per-VLAN basis.

Global IGMP snooping overrides the VLAN IGMP snooping. If global snooping is disabled, you cannot enable VLAN snooping. If global snooping is enabled, you can enable or disable VLAN snooping.

Beginning in privileged EXEC mode, follow these steps to globally enable IGMP snooping on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip igmp snooping**	Globally enable IGMP snooping in all existing VLAN interfaces.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To globally disable IGMP snooping on all VLAN interfaces, use the **no ip igmp snooping** global configuration command.

Beginning in privileged EXEC mode, follow these steps to enable IGMP snooping on a VLAN interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip igmp snooping vlan** *vlan-id*	Enable IGMP snooping on the VLAN interface.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable IGMP snooping on a VLAN interface, use the **no ip igmp snooping vlan** *vlan-id* global configuration command for the specified VLAN number.

Setting the Snooping Method

Multicast-capable router ports are added to the forwarding table for every Layer 2 multicast entry. The switch learns of such ports through one of these methods:

- Snooping on IGMP queries, Protocol Independent Multicast (PIM) packets, and Distance Vector Multicast Routing Protocol (DVMRP) packets
- Listening to Cisco Group Management Protocol (CGMP) packets from other routers
- Statically connecting to a multicast router port with the **ip igmp snooping mrouter** global configuration command

You can configure the switch either to snoop on IGMP queries and PIM/DVMRP packets or to listen to CGMP self-join or proxy-join packets. By default, the switch snoops on PIM/DVMRP packets on all VLANs. To learn of multicast router ports through only CGMP packets, use the **ip igmp snooping vlan** *vlan-id* **mrouter learn cgmp** global configuration command. When this command is entered, the router listens to only CGMP self-join and CGMP proxy-join packets and no other CGMP packets. To learn of multicast router ports through only PIM-DVMRP packets, use the **ip igmp snooping vlan** *vlan-id* **mrouter learn pim-dvmrp** global configuration command.

Beginning in privileged EXEC mode, follow these steps to alter the method in which a VLAN interface dynamically accesses a multicast router:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip igmp snooping vlan** *vlan-id* **mrouter learn** {**cgmp** | **pim-dvmrp**}	Enable IGMP snooping on a VLAN.The VLAN ID range is 1 to 1005 when the standard software image (SI) is installed and 1 to 4094 when the enhanced software image (EI) is installed. Specify the multicast router learning method: • **cgmp**—Listen for CGMP packets. This method is useful for reducing control traffic. • **pim-dvmrp**—Snoop on IGMP queries and PIM-DVMRP packets. This is the default.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show ip igmp snooping**	Verify the configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to configure IGMP snooping to use CGMP packets as the learning method:

```
Switch# configure terminal
Switch(config)# ip igmp snooping vlan 1 mrouter learn cgmp
Switch(config)# end
Switch# show ip igmp snooping vlan 1
vlan 1
----------
 IGMP snooping is globally enabled
 IGMP snooping is enabled on this Vlan
 IGMP snooping immediate-leave is disabled on this Vlan
 IGMP snooping mrouter learn mode is cgmp on this Vlan
 IGMP snooping is running in IGMP_ONLY mode on this Vlan
```

To return to the default learning method, use the **no ip igmp snooping vlan** *vlan-id* **mrouter learn cgmp** global configuration command.

Configuring a Multicast Router Port

To add a multicast router port (add a static connection to a multicast router), use the **ip igmp snooping vlan mrouter** global configuration command on the switch.

Beginning in privileged EXEC mode, follow these steps to enable a static connection to a multicast router:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip igmp snooping vlan** *vlan-id* **mrouter interface** *interface-id*	Specify the multicast router VLAN ID and specify the interface to the multicast router. For the VLAN ID , the range is 1 to 1005 when the SI is installed and 1 to 4094 when the EI is installed.
Step 3	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 4	**show ip igmp snooping mrouter** [**vlan** *vlan-id*]	Verify that IGMP snooping is enabled on the VLAN interface.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a multicast router port from the VLAN, use the **no ip igmp snooping vlan** *vlan-id* **mrouter interface** *interface-id* global configuration command.

This example shows how to enable a static connection to a multicast router and verify the configuration:

```
Switch# configure terminal
Switch(config)# ip igmp snooping vlan 200 mrouter interface gigabitethernet0/2
Switch(config)# end
Switch# show ip igmp snooping mrouter vlan 200
vlan            ports
-----+---------------------------------------
 200           Gi0/2(static)
```

Configuring a Host Statically to Join a Group

Hosts or Layer 2 ports normally join multicast groups dynamically, but you can also statically configure a host on an interface.

Beginning in privileged EXEC mode, follow these steps to add a Layer 2 port as a member of a multicast group:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-id*	Statically configure a Layer 2 port as a member of a multicast group: • *vlan-id* is the multicast group VLAN ID. • *mac-address* is the group MAC address. • *interface-id* is the member port.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show ip igmp snooping mrouter vlan** *vlan-id* or **show mac address-table multicast vlan** *vlan-id*	Verify that the member port is a member of the VLAN multicast group. Verify the member port and the MAC address
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the Layer 2 port from the multicast group, use the **no ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-id* global configuration command.

This example shows how to statically configure a host on an interface and verify the configuration:

```
Switch# configure terminal
Switch(config)# ip igmp snooping vlan 1 static 0100.5e00.0203 interface gigabitethernet0/1
Switch(config)# end
Switch# show mac address-table multicast vlan 1
Vlan    Mac Address       Type       Ports
----    -----------       ----       -----
   1    0100.5e00.0203    USER       Gi0/1
```

Enabling IGMP Immediate-Leave Processing

When you enable IGMP Immediate-Leave processing, the switch immediately removes a port when it detects an IGMP version 2 leave message on that port. You should use the Immediate-Leave feature only when there is a single receiver present on every port in the VLAN.

Immediate Leave is supported with only IGMP version 2 hosts.

Beginning in privileged EXEC mode, follow these steps to enable IGMP Immediate-Leave processing:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**ip igmp snooping vlan** *vlan-id* **immediate-leave**	Enable IGMP Immediate-Leave processing on the VLAN interface.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show ip igmp snooping vlan** *vlan-id*	Verify that Immediate Leave is enabled on the VLAN.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable IGMP Immediate-Leave on a VLAN, use the **no ip igmp snooping vlan** *vlan-id* **immediate-leave** global configuration command.

This example shows how to enable IGMP immediate-leave processing on VLAN 130 and verify the configuration:

```
Switch# configure terminal
Switch(config)# ip igmp snooping vlan 130 immediate-leave
Switch(config)# end
Switch# show ip igmp snooping vlan 130
vlan 130
----------
 IGMP snooping is globally enabled
 IGMP snooping is enabled on this Vlan
 IGMP snooping immediate-leave is enabled on this Vlan
 IGMP snooping mrouter learn mode is pim-dvmrp on this Vlan
 IGMP snooping is running in IGMP_ONLY mode on this Vlan
```

Disabling IP Multicast-Source-Only Learning

The IP multicast-source-only learning method is enabled by default. The switch learns the IP multicast group from the IP multicast data stream and only forwards traffic to the multicast router ports.

If IP multicast-source-only learning is disabled by using the **ip igmp snooping source-only-learning** global configuration command, the switch floods unknown multicast traffic to the VLAN and sends the traffic to the CPU until the traffic becomes known. When the switch receives an IGMP report from a host for a particular multicast group, the switch forwards traffic from this multicast group only to the multicast router ports.

Note We strongly recommend that you do not disable IP multicast-source-only learning. IP multicast-source-only learning should be disabled only if your network is not composed of IP multicast-source-only networks and if disabling this learning method improves the network performance.

Beginning in privileged EXEC mode, follow these steps to disable IP multicast-source-only learning:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**no ip igmp snooping source-only-learning**	Disable IP multicast-source-only learning.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config | include source-only-learning**	Verify that IP multicast-source-only learning is disabled.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To enable IP multicast-source-only learning, use the **ip igmp snooping source-only-learning** global configuration command.

This example shows how to disable IP multicast-source-only learning and verify the configuration:

```
Switch# configure terminal
Switch(config)# no ip igmp snooping source-only-learning
Switch(config)# end
Switch# show running-config | include source-only-learning
Current configuration : 1972 bytes
!
version 12.1
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Switch
!
enable password my_password
!
ip subnet-zero
no ip igmp snooping source-only-learning
!
!
spanning-tree extend system-id
no spanning-tree vlan 1
!
!
interface FastEthernet0/1
 no ip address
!
<output truncated>
```

Displaying IGMP Snooping Information

You can display IGMP snooping information for dynamically learned and statically configured router ports and VLAN interfaces. You can also display MAC address multicast entries for a VLAN configured for IGMP snooping.

To display IGMP snooping information, use one or more of the privileged EXEC commands in Table 18-4.

Table 18-4 Commands for Displaying IGMP Snooping Information

Command	Purpose
show ip igmp snooping [**vlan** *vlan-id*]	Display the snooping configuration information for all VLANs on the switch or for a specified VLAN. (Optional) Enter **vlan** *vlan-id* to display information for a single VLAN.
show ip igmp snooping mrouter [**vlan** *vlan-id*]	Display information on dynamically learned and manually configured multicast router interfaces. **Note** When you enable IGMP snooping, the switch automatically learns the interface to which a multicast router is connected. These are dynamically learned interfaces. (Optional) Enter **vlan** *vlan-id* to display information for a single VLAN.
show mac address-table multicast [**vlan** *vlan-id*] [**user** | **igmp-snooping**] [**count**]	Display the Layer 2 MAC address table entries for a VLAN. The keywords are all optional and limit the display as shown: • **vlan** *vlan-id*—Displays only the specified multicast group VLAN. • **user**—Displays only the user-configured multicast entries. • **igmp-snooping**—Displays only entries learned through IGMP snooping. • **count**—Displays only the total number of entries for the selected criteria, not the actual entries.

This is an example of output from the **show ip igmp snooping** privileged EXEC command for all VLAN interfaces on the switch:

```
Switch# show ip igmp snooping
vlan 1
----------
 IGMP snooping is globally enabled
 IGMP snooping is enabled on this Vlan
 IGMP snooping immediate-leave is disabled on this Vlan
 IGMP snooping mrouter learn mode is pim-dvmrp on this Vlan
 IGMP snooping is running in IGMP_ONLY mode on this Vlan
vlan 2
----------
 IGMP snooping is globally enabled
 IGMP snooping is enabled on this Vlan
 IGMP snooping immediate-leave is disabled on this Vlan
 IGMP snooping mrouter learn mode is pim-dvmrp on this Vlan
 IGMP snooping is running in IGMP_ONLY mode on this Vlan
vlan 10
----------
 IGMP snooping is globally enabled
 IGMP snooping is enabled on this Vlan
 IGMP snooping immediate-leave is disabled on this Vlan
 IGMP snooping mrouter learn mode is pim-dvmrp on this Vlan
 IGMP snooping is running in IGMP_ONLY mode on this Vlan
```

This is an example of output from the **show ip igmp snooping** privileged EXEC command for a specific VLAN interface:

```
Switch# show ip igmp snooping vlan 1
vlan 1
----------
  IGMP snooping is globally enabled
  IGMP snooping is disabled on this Vlan
  IGMP snooping immediate-leave is disabled on this Vlan
  IGMP snooping mrouter learn mode is pim-dvmrp on this Vlan
```

This is an example of output from the **show ip igmp snooping mrouter** privileged EXEC command for VLAN 1:

```
Switch# show ip igmp snooping mrouter vlan 1
Vlan    ports
----    -----
   1    Gi0/1(dynamic)
   1    Gi0/2(dynamic)
```

This example shows how to display the Layer 2 multicast entries for VLAN 1:

```
Switch# show mac address-table multicast vlan 1
vlan   mac address     type         ports
-----+---------------+--------+---------+---+--------------------------------
  1  0100.5e02.0203    user           Gi0/1,Gi0/2
  1  0100.5e00.0127    igmp           Gi0/1,Gi0/2
  1  0100.5e00.0128    user           Gi0/1,Gi0/2
  1  0100.5e00.0001    igmp           Gi0/1,Gi0/2
```

This is an example of output from the **show mac address-table multicast count** privileged EXEC command for the switch:

```
Switch# show mac address-table multicast count

Multicast MAC Entries for all vlans:    10
```

This is an example of output from the **show mac address-table multicast count** privileged EXEC command for a VLAN:

```
Switch# show mac address-table multicast vlan 1 count

Multicast MAC Entries for vlan 1:
```

This example shows how to display only the user-configured multicast entries for VLAN 1:

```
Switch# show mac address-table multicast vlan 1 user
vlan   mac address     type         ports
-----+---------------+--------+---------+---+--------------------------------
  1  0100.5e02.0203    user           Gi0/1,Gi0/2
  1  0100.5e00.0128    user           Gi0/1,Gi0/2
```

This example shows how to display the total number of entries learned by IGMP snooping for VLAN 1:

```
Switch# show mac address-table multicast vlan 1 igmp-snooping count

Number of user programmed entries:    2
```

Understanding Multicast VLAN Registration

Multicast VLAN Registration (MVR) is designed for applications using wide-scale deployment of multicast traffic across an Ethernet ring-based service provider network (for example, the broadcast of multiple television channels over a service-provider network). MVR allows a subscriber on a port to subscribe and unsubscribe to a multicast stream on the network-wide multicast VLAN. It allows the single multicast VLAN to be shared in the network while subscribers remain in separate VLANs. MVR provides the ability to continuously send multicast streams in the multicast VLAN, but to isolate the streams from the subscriber VLANs for bandwidth and security reasons.

MVR assumes that subscriber ports subscribe and unsubscribe (join and leave) these multicast streams by sending out IGMP join and leave messages. These messages can originate from an IGMP version-2-compatible host with an Ethernet connection. Although MVR operates on the underlying mechanism of IGMP snooping, the two features operate independently of each other. One can be enabled or disabled without affecting the behavior of the other feature. However, if IGMP snooping and MVR are both enabled, MVR reacts only to join and leave messages from multicast groups configured under MVR. Join and leave messages from all other multicast groups are managed by IGMP snooping.

The switch CPU identifies the MVR IP multicast streams and their associated MAC addresses in the switch forwarding table, intercepts the IGMP messages, and modifies the forwarding table to include or remove the subscriber as a receiver of the multicast stream, even though the receivers might be in a different VLAN from the source. This forwarding behavior selectively allows traffic to cross between different VLANs.

The switch has these modes of MVR operation: dynamic and compatible.

- When operating in MVR dynamic mode, the switch performs standard IGMP snooping. IGMP information packets are sent to the switch CPU, but multicast data packets are not sent to the CPU. Dynamic mode allows the multicast router to run normally because the switch sends the IGMP join messages to the router, and the router forwards multicast streams for a particular group to an interface only if it has received a join message from the interface for the group. Receiver ports are treated as members of the multicast VLAN for MVR multicast control and data traffic. IGMP reports for MVR groups are sent out source ports in the multicast VLAN.
- When in MVR compatible mode, MVR on the Catalyst 3550 switch interoperates with MVR on Catalyst 3500 XL and Catalyst 2900 XL switches. It works the same as dynamic mode for all multicast data packets and IGMP query and leave packets. However, received IGMP report packets for MVR groups are not sent out on the multicast VLAN source ports. In contrast to dynamic mode, the switch does not send join messages to the router. The router must be statically configured for the interface to receive the multicast stream. Therefore, in this mode, MVR does not support dynamic membership joins on source ports.

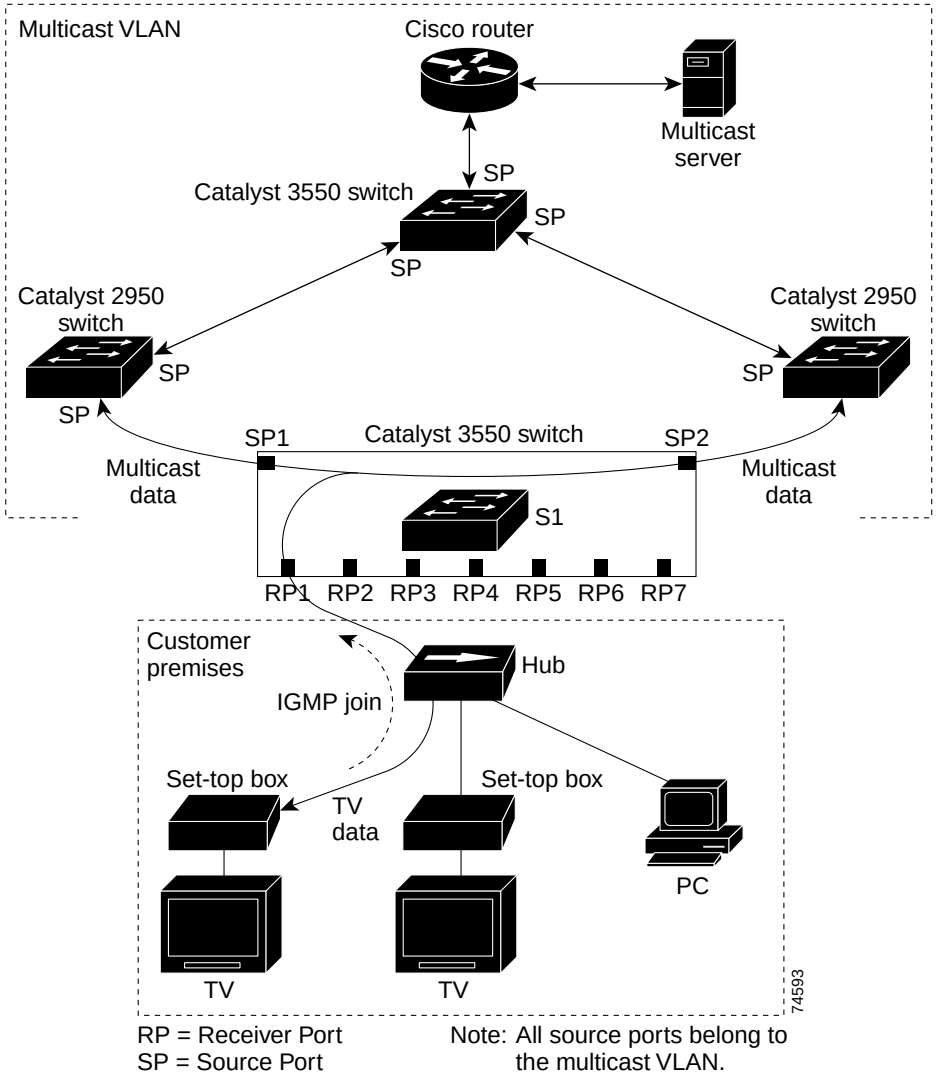
Using MVR in a Multicast Television Application

In a multicast television application, a PC or a television with a set-top box can receive the multicast stream. Multiple set-top boxes or PCs can be connected to one subscriber port, which is a switch port configured as an MVR receiver port. See Figure 18-3. DHCP assigns an IP address to the set-top box or the PC. When a subscriber selects a channel, the set-top box or PC sends an IGMP report to the S1 switch to join the appropriate multicast. If the IGMP report matches one of the configured multicast MAC addresses, the switch CPU modifies the hardware address table to include this receiver port and VLAN as a forwarding destination of the specified multicast stream when it is received from the multicast VLAN. Uplink ports that send and receive multicast data to and from the multicast VLAN are called MVR source ports.

When a subscriber changes channels or turns off the television, the set-top box sends an IGMP leave message for the multicast stream. The switch CPU sends an IGMP group-specific query through the receiver port VLAN. If there is another set-top box in the VLAN still subscribing to this group, that set-top box must respond within the maximum response time. If the CPU does not receive a response, it eliminates the receiver port as a forwarding destination for this group.

If the Immediate-Leave feature is enabled on a receiver port, the port leaves a multicast group more quickly. Without Immediate Leave, when the switch receives an IGMP leave message from a subscriber on a receiver port, it sends out an IGMP query on that port and waits for IGMP group membership reports. If no reports are received in a configured time period, the receiver port is removed from multicast group membership. With Immediate Leave, an IGMP query is not sent from the receiver port on which the IGMP leave was received. As soon as the leave message is received, the receiver port is removed from multicast group membership, which speeds up leave latency. Enable the Immediate Leave feature only on receiver ports to which a single receiver device is connected.

Figure 18-3 Multicast VLAN Registration Example



MVR eliminates the need to duplicate television-channel multicast traffic for subscribers in each VLAN. Multicast traffic for all channels is only sent around the VLAN trunk once—only on the multicast VLAN. Although the IGMP leave and join message in the VLAN to which the subscriber port is assigned. These messages dynamically register for streams of multicast traffic in the multicast VLAN on the Layer 3 device. The access layer switch (S1 switch) modifies the forwarding behavior to allow the traffic to be forwarded from the multicast VLAN to the subscriber port in a different VLAN, selectively allowing traffic to cross between two VLANs.

IGMP reports are sent to the same MAC addresses as the multicast data. The S1 CPU must capture all IGMP join and leave messages from receiver ports and forward them to the multicast VLAN of the source (uplink) port.

Configuring MVR

These sections include basic MVR configuration information:

- Default MVR Configuration, page 18-15
- MVR Configuration Guidelines and Limitations, page 18-16
- Configuring MVR Global Parameters, page 18-16
- Configuring MVR Interfaces, page 18-17

Default MVR Configuration

Table 18-5 shows the default MVR configuration.

Table 18-5 Default MVR Configuration

Feature	Default Setting
MVR	Disabled globally and per interface
Multicast addresses	None configured
Query response time	0.5 second
Multicast VLAN	VLAN 1
Mode	Compatible
Interface (per port) default	Neither a receiver nor a source port
Immediate Leave	Disabled on all ports

MVR Configuration Guidelines and Limitations

Follow these guidelines when configuring MVR:

- Receiver ports cannot be trunk ports. Receiver ports on a switch can be in different VLANs, but should not belong to the multicast VLAN.
- The maximum number of multicast entries that can be configured on a switch (that is, the maximum number of television channels that can be received) is 256.
- Each channel is one multicast stream destined for a unique IP multicast address. These IP addresses cannot alias between themselves or with the reserved IP multicast addresses (in the range 224.0.0.xxx).

Note For complete syntax and usage information for the commands used in this section, refer to the command reference for this release.

Configuring MVR Global Parameters

You do not need to set the optional MVR parameters if you choose to use the default settings. If you do want to change the default parameters (except for the MVR VLAN), you must first enable MVR.

Beginning in privileged EXEC mode, follow these steps to configure MVR parameters:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mvr**	Enable MVR on the switch.
Step 3	**mvr group** *ip-address* [*count*]	Configure an IP multicast address on the switch or use the *count* parameter to configure a contiguous series of MVR group addresses (the range for *count* is 1 to 256; the default is 1). Any multicast data sent to this address is sent to all source ports on the switch and all receiver ports that have elected to receive data on that multicast address. Each multicast address would correspond to one television channel. **Note** Each IP address translates to a multicast 48-bit MAC address. If an IP address being configured translates (aliases) to a previously configured MAC address or to any reserved multicast MAC addresses, the command fails.
Step 4	**mvr querytime** *value*	(Optional) Define the maximum time to wait for IGMP report memberships on a receiver port before removing the port from multicast group membership. The value is in units of tenths of a second. The range is from 1 to 100 and the default is 5 tenths or one-half second.
Step 5	**mvr vlan** *vlan-id*	(Optional) Specify the VLAN in which multicast data is received; all source ports must belong to this VLAN. The VLAN range is 1 to 4094. The default is VLAN 1.

	Command	Purpose
Step 6	**mvr mode** {**dynamic** | **compatible**}	(Optional) Specify the MVR mode of operation: • **dynamic**—Allows dynamic MVR membership on source ports. • **compatible**—Is compatible with Catalyst 3500 XL and Catalyst 2900 XL switches and does not support IGMP dynamic joins on source ports. The default is **compatible** mode.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show mvr** or **show mvr members**	Verify the configuration.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the switch to its default settings, use the **no mvr** [**mode** | **group** *ip-address* | **querytime** | **vlan**] global configuration commands.

This example shows how to enable MVR, configure the MVR group address, set the query time to 1 second (10 tenths), specify the MVR multicast VLAN as VLAN 22, set the MVR mode as dynamic, and verify the results:

```
Switch(config)# mvr
Switch(config)# mvr group 228.1.23.4
Switch(config)# mvr querytime 10
Switch(config)# mvr vlan 22
Switch(config)# mvr mode dynamic
Switch(config)# end
Switch# show mvr
MVR Running: TRUE
MVR multicast vlan: 22
MVR Max Multicast Groups: 256
MVR Current multicast groups: 1
MVR Global query response time: 10 (tenths of sec)
MVR Mode: dynamic
```

You can use the **show mvr members** privileged EXEC command to verify the MVR multicast group addresses on the switch.

Configuring MVR Interfaces

Beginning in privileged EXEC mode, follow these steps to configure MVR interfaces:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mvr**	Enable MVR on the switch.
Step 3	**interface** *interface-id*	Enter interface configuration mode, and enter the type and number of the port to configure; for example, enter **gi0/1** or **gigabitethernet 0/1** for Gigabit Ethernet port 1.

	Command	Purpose
Step 4	**mvr type** {**source** | **receiver**}	Configure an MVR port as one of these: • **source**—Configure uplink ports that receive and send multicast data as source ports. Subscribers cannot be directly connected to source ports. All source ports on a switch belong to the single multicast VLAN. • **receiver**—Configure a port as a receiver port if it is a subscriber port and should only receive multicast data. It does not receive data unless it becomes a member of the multicast group, either statically or by using IGMP leave and join messages. Receiver ports cannot belong to the multicast VLAN. The default configuration is as a non-MVR port. If you attempt to configure a non-MVR port with MVR characteristics, the operation fails.
Step 5	**mvr vlan** *vlan-id* **group** *ip-address*	(Optional) Statically configure a port to receive multicast traffic sent to the multicast VLAN and the IP multicast address. A port statically configured as a member of a group remains a member of the group until statically removed. **Note** In compatible mode, this command applies to only receiver ports. In dynamic mode, it applies to receiver ports and source ports. Receiver ports can also dynamically join multicast groups by using IGMP join and leave messages.
Step 6	**mvr immediate**	(Optional) Enable the Immediate Leave feature of MVR on the port. **Note** This command applies to only receiver ports and should only be enabled on receiver ports to which a single receiver device is connected.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show mvr** **show mvr interface** or **show mvr members**	Verify the configuration.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the interface to its default settings, use the **no mvr** [**type** | **immediate** | **vlan** *vlan-id* | **group**] interface configuration commands.

This example shows how to configure Gigabit Ethernet port 0/2 as a receiver port, statically configure the port to receive multicast traffic sent to the multicast group address, configure Immediate Leave on the interface, and verify the results.

```
Switch(config)# mvr
Switch(config)# interface gigabitethernet0/2
Switch(config-if)# mvr type receiver
Switch(config-if)# mvr vlan 22 group 228.1.23.4
Switch(config-if)# mvr immediate
Switch(config)# end
Switch# show mvr interface gigabitethernet0/2
Type: RECEIVER Status: ACTIVE Immediate Leave: ENABLED
```

This is an example of output from the **show mvr interface** privileged EXEC command when the **member** keyword is included:

```
Switch# show mvr interface fastethernet0/2 members
224.0.1.1       DYNAMIC ACTIVE
```

Displaying MVR Information

You can display MVR information for the switch or for a specified interface.

Beginning in privileged EXEC mode, use the commands in Table 18-6 to display MVR configuration:

Table 18-6 Commands for Displaying MVR Information

show mvr	Displays MVR status and values for the switch—whether MVR is enabled or disabled, the multicast VLAN, the maximum (256) and current (0 through 256) number of multicast groups, the query response time, and the MVR mode.
show mvr interface [*interface-id*] [**members** [**vlan** *vlan-id*]]	Displays all MVR interfaces and their MVR configurations. When a specific interface is entered, displays this information: • Type—Receiver or Source • Status—One of these: – Active means the port is part of a VLAN. – Up/Down means that the port is forwarding or nonforwarding. – Inactive means that the port is not part of any VLAN. • Immediate Leave—Enabled or Disabled If the **members** keyword is entered, displays all multicast group members on this port or, if a VLAN identification is entered, all multicast group members on the VLAN. The VLAN ID range is 1 to 1005 when the SI is installed and 1 to 4094 when the EI is installed.
show mvr members [*ip-address*]	Displays all receiver and source ports that are members of any IP multicast group or the specified IP multicast group IP address.

This is an example of output from the **show mvr** privileged EXEC command:

```
Switch# show mvr
MVR Running: TRUE
MVR multicast vlan: 1
MVR Max Multicast Groups: 256
MVR Current multicast groups: 256
MVR Global query response time: 5 (tenths of sec)
MVR Mode: compatible
```

This is an example of output from the **show mvr interface** privileged EXEC command:

```
Switch# show mvr interface
Port    Type            Status          Immediate Leave
----   ----       -------     --------------
Fa0/1   SOURCE          ACTIVE/UP       DISABLED
Fa0/2   SOURCE          ACTIVE/UP       DISABLED
Fa0/3   SOURCE          ACTIVE/DOWN     DISABLED
Fa0/5   SOURCE          ACTIVE/DOWN     DISABLED
```

This is an example of output from the **show mvr interface** privileged EXEC command for a specified interface:

```
Switch# show mvr interface fastethernet0/2
224.0.1.1       DYNAMIC ACTIVE
```

This is an example of output from the **show mvr interface** privileged EXEC command when the **members** keyword is included:

```
Switch# show mvr interface fastethernet0/2 members
224.0.1.1       DYNAMIC ACTIVE
```

This is an example of output from the **show mvr members** privileged EXEC command:

```
Switch# show mvr members
MVR Group IP    Status          Members
------------    ------          -------
224.0.1.1       ACTIVE          Fa0/1(s), Fa0/2(d)
224.0.1.2       ACTIVE          Fa0/1(s)
224.0.1.3       ACTIVE          Fa0/1(s)
224.0.1.4       ACTIVE          Fa0/1(s)
224.0.1.5       ACTIVE          Fa0/1(s)
<output truncated>
```

Configuring IGMP Filtering

In some environments, for example metropolitan or multiple-dwelling unit (MDU) installations, an administrator might want to control the set of multicast groups to which a user on a switch port can belong. This allows the administrator to control the distribution of multicast services, such as IP/TV, based on some type of subscription or service plan. With the IGMP filtering feature, you can filter multicast joins on a per-port basis by configuring IP multicast profiles and associating them with individual switch ports. An IGMP profile can contain one or more multicast groups and specifies whether access to the group is permitted or denied. If an IGMP profile denying access to a multicast group is applied to a switch port, the IGMP join report requesting the stream of IP multicast traffic is dropped, and the port is not allowed to receive IP multicast traffic from that group. If the filtering action permits access to the multicast group, the IGMP report from the port is forwarded for normal processing.

IGMP filtering controls only group specific query and membership reports, including join and leave reports. It does not control general IGMP queries. IGMP filtering has no relationship with the function that directs the forwarding of IP multicast traffic. The filtering feature operates in the same manner whether CGMP or MVR is used to forward the multicast traffic.

You can also set the maximum number of IGMP groups that a Layer 2 interface can join.

Default IGMP Filtering Configuration

Table 18-7 shows the default IGMP filtering configuration.

Table 18-7 Default IGMP Filtering Configuration

Feature	Default Setting
IGMP filters	None applied
IGMP Maximum number of IGMP groups	No maximum set

Table 18-7 Default IGMP Filtering Configuration (continued)

Feature	Default Setting
IGMP profiles	None defined
IGMP profile action	Deny the range addresses

Configuring IGMP Profiles

To configure an IGMP profile, use the **ip igmp profile** global configuration command with a profile number to create an IGMP profile and to enter IGMP profile configuration mode. From this mode, you can specify the parameters of the IGMP profile to be used for filtering IGMP join requests from a port. When you are in IGMP profile configuration mode, you can create the profile by using these commands:

- **deny**: Specifies that matching addresses are denied; this is the default condition.
- **exit**: Exits from igmp-profile configuration mode.
- **no**: Negates a command or sets its defaults.
- **permit**: Specifies that matching addresses are permitted.
- **range**: Specifies a range of IP addresses for the profile. You can enter a single IP address or a range with a start and an end address.

The default is for the switch to have no IGMP profiles configured. When a profile is configured, if neither the **permit** nor **deny** keyword is included, the default is to deny access to the range of IP addresses.

Beginning in privileged EXEC mode, follow these steps to create an IGMP profile:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip igmp profile** *profile number*	Enter IGMP profile configuration mode, and assign a number to the profile you are configuring. The range is from 1 to 4294967295.
Step 3	**permit** | **deny**	(Optional) Set the action to permit or deny access to the IP multicast address. If no action is configured, the default for the profile is to deny access.
Step 4	**range** *ip multicast address*	Enter the IP multicast address or range of IP multicast addresses to which access is being controlled. If entering a range, enter the low IP multicast address, a space, and the high IP multicast address. You can use the **range** command multiple times to enter multiple addresses or ranges of addresses.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show ip igmp profile** *profile number*	Verify the profile configuration.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete a profile, use the **no ip igmp profile** *profile number* global configuration command.

To delete an IP multicast address or range of IP multicast addresses, use the **no range** *ip multicast address* IGMP profile configuration command.

This example shows how to create IGMP profile 4 allowing access to the single IP multicast address and how to verify the configuration. If the action was to deny (the default), it would not appear in the **show ip igmp profile** output display.

```
Switch(config)# ip igmp profile 4
Switch(config-igmp-profile)# permit
Switch(config-igmp-profile)# range 229.9.9.0
Switch(config-igmp-profile)# end
Switch# show ip igmp profile 4
IGMP Profile 4
    permit
    range 229.9.9.0 229.9.9.0
```

Applying IGMP Profiles

To control access as defined in an IGMP profile, use the **ip igmp filter** interface configuration command to apply the profile to the appropriate interfaces. You can apply IGMP profiles to Layer 2 ports only. You cannot apply profiles to ports that belong to an EtherChannel port group. You can apply a profile to multiple interfaces, but each interface can only have one profile applied to it.

Beginning in privileged EXEC mode, follow these steps to apply an IGMP profile to a switch port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and enter the physical interface to configure, for example **fastethernet0/3**. The interface must be a Layer 2 port that does not belong to an EtherChannel port group.
Step 3	**ip igmp filter** *profile number*	Apply the specified IGMP profile to the interface. The profile number can be from 1 to 4294967295.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running configuration interface** *interface-id*	Verify the configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a profile from an interface, use the **no ip igmp filter** *profile number* interface configuration command.

This example shows how to apply IGMP profile 4 to an interface and verify the configuration.

```
Switch(config)# interface fastethernet0/12
Switch(config-if)# ip igmp filter 4
Switch(config-if)# end
Switch# show running-config interface fastethernet0/12
Building configuration...

Current configuration : 123 bytes
!
interface FastEthernet0/12
 no ip address
 shutdown
 snmp trap link-status
 ip igmp max-groups 25
 ip igmp filter 4
end
```

Setting the Maximum Number of IGMP Groups

You can set the maximum number of IGMP groups that a Layer 2 interface can join by using the **ip igmp mac-groups** interface configuration command. Use the **no** form of this command to set the maximum back to the default, which is no limit.

You cannot use this command on ports that belong to an EtherChannel port group.

Beginning in privileged EXEC mode, follow these steps to apply an IGMP profile to a switch port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and enter the physical interface to configure, for example **gigabitethernet0/1**. The interface must be a Layer 2 port that does not belong to an EtherChannel group.
Step 3	**ip igmp max-groups** *number*	Set the maximum number of IGMP groups that the interface can join. The range is from 0 to 4294967294. The default is to have no maximum set.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-configuration interface** *interface-id*	Verify the configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the maximum group limitation and return to the default of no maximum, use the **no ip igmp max-groups** interface configuration command.

This example shows how to limit the number of IGMP groups that an interface can join to 25.

```
Switch(config)# interface fastethernet0/12
Switch(config-if)# ip igmp max-groups 25
Switch(config-if)# end
Switch# show running-config interface fastethernet0/12
Building configuration...

Current configuration : 123 bytes
!
interface FastEthernet0/12
 no ip address
 shutdown
 snmp trap link-status
 ip igmp max-groups 25
 ip igmp filter 4
end
```

Displaying IGMP Filtering Configuration

You can display IGMP profile characteristics, and you can display the IGMP profile and maximum group configuration for all interfaces on the switch or for a specified interface.

Use the privileged EXEC commands in Table 18-8 to display IGMP filtering configuration:

Table 18-8 Commands for Displaying IGMP Filtering Configuration

show ip igmp profile [*profile number***]**	Displays the specified IGMP profile or all IGMP profiles defined on the switch.
show running-configuration [**interface** *interface-id*]	Displays the configuration of the specified interface or all interfaces on the switch, including (if configured) the maximum number of IGMP groups to which an interface can belong and the IGMP profile applied to the interface.

This is an example of the **show ip igmp profile** privileged EXEC command when no profile number is entered. All profiles defined on the switch are displayed.

```
Switch# show ip igmp profile
IGMP Profile 3
    range 230.9.9.0 230.9.9.0
IGMP Profile 4
    permit
    range 229.9.9.0 229.255.255.255
```

This is an example of the output from the **show running-config** privileged EXEC command when an interface is specified with IGMP maximum groups configured and IGMP profile 4 has been applied to the interface.

```
Switch# show running-config interface fastethernet0/12
Building configuration...
Current configuration : 123 bytes
!
interface FastEthernet0/12
 no ip address
 shutdown
 snmp trap link-status
 ip igmp max-groups 25
 ip igmp filter 4
end
```

CHAPTER 19

Configuring Port-Based Traffic Control

This chapter describes how to configure the port-based traffic control features on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Configuring Storm Control, page 19-1
- Configuring Protected Ports, page 19-3
- Configuring Port Security, page 19-4
- Displaying Port-Based Traffic Control Settings, page 19-11

Configuring Storm Control

These sections include storm control configuration information and procedures:

- Understanding Storm Control, page 19-1
- Default Storm Control Configuration, page 19-2
- Enabling Storm Control, page 19-2
- Disabling Storm Control, page 19-3

Understanding Storm Control

A packet storm occurs when a large number of broadcast, unicast, or multicast packets are received on a port. Forwarding these packets can cause the network to slow down or to time out. Storm control is configured for the switch as a whole but operates on a per-port basis. By default, storm control is disabled.

Storm control uses rising and falling thresholds to block and then restore the forwarding of broadcast, unicast, or multicast packets. You can also set the switch to shut down the port when the rising threshold is reached.

Storm control uses a bandwidth-based method to measure traffic activity. The thresholds are expressed as a percentage of the total available bandwidth that can be used by the broadcast, multicast, or unicast traffic.

The rising threshold is the percentage of total available bandwidth associated with multicast, broadcast, or unicast traffic before forwarding is blocked. The falling threshold is the percentage of total available bandwidth below which the switch resumes normal forwarding. In general, the higher the level, the less effective the protection against broadcast storms.

Default Storm Control Configuration

By default, broadcast, multicast, and unicast storm control is disabled on the switch. The default action is to filter traffic and to not send an SNMP trap.

Enabling Storm Control

Beginning in privileged EXEC mode, follow these steps to enable storm control:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the port to configure, and enter interface configuration mode.
Step 3	**storm-control** {**broadcast** | **multicast** | **unicast**} **level** *level* [*level-low*]	Configure broadcast, multicast, or unicast storm control. Specify the rising threshold level for broadcast, multicast, or unicast traffic. The storm control action occurs when traffic utilization reaches this level. (Optional) Specify the falling threshold level. The normal transmission restarts (if the action is filtering) when traffic drops below this level.
Step 4	**storm-control action** {**shutdown** | **trap**}	Specify the action to be taken when a storm is detected. The default is to filter out the traffic and not to send traps. Select the **shutdown** keyword to error-disable the port during a storm. Select the **trap** keyword to generate an SNMP trap when a storm is detected.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show storm-control** [**interface**] [{**broadcast** | **history** | **multicast** | **unicast**}]	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Disabling Storm Control

Beginning in privileged EXEC mode, follow these steps to disable storm control:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the port to configure, and enter interface configuration mode.
Step 3	**no storm-control** {**broadcast** | **multicast** | **unicast**} level	Disable port storm control.
Step 4	**no storm-control action** {**shutdown** | **trap**}	Disable the specified storm control action.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show storm-control** {**broadcast** | **multicast** | **unicast**}	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Configuring Protected Ports

Some applications require that no traffic be forwarded between ports on the same switch so that one neighbor does not see the traffic generated by another neighbor. In such an environment, the use of protected ports ensures that there is no exchange of unicast, broadcast, or multicast traffic between these ports on the switch.

Protected ports have these features:

- A protected port does not forward any traffic (unicast, multicast, or broadcast) to any other port that is also a protected port. Traffic cannot be forwarded between protected ports at Layer 2; all traffic passing between protected ports must be forwarded through a Layer 3 device.
- Forwarding behavior between a protected port and a nonprotected port proceeds as usual.

The default is to have no protected ports defined.

You can configure protected ports on a physical interface (for example, Gigabit Ethernet 0/1) or an EtherChannel group (for example, port-channel 5). When you enable protected ports for a port channel, it is enabled for all ports in the port-channel group.

Beginning in privileged EXEC mode, follow these steps to define a port as a protected port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the type and number of the physical interface to configure, for example **gigabitethernet0/1**, and enter interface configuration mode.
Step 3	**switchport protected**	Configure the interface to be a protected port.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** *interface-id* **switchport**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable protected port, use the **no switchport protected** interface configuration command.

This example shows how to configure Gigabit Ethernet interface 0/1 as a protected port and verify the configuration:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# switchport protected
Switch(config-if)# end
Switch# show interfaces gigabitethernet0/1 switchport
Name: Gi0/1
Switchport: Enabled

<output truncated>

Protected: True
Unknown unicast blocked: disabled
Unknown multicast blocked: disabled
```

Configuring Port Security

You can use the port security feature to restrict input to an interface by limiting and identifying MAC addresses of the stations allowed to access the port. When you assign secure MAC addresses to a secure port, the port does not forward packets with source addresses outside the group of defined addresses.

This section includes information about these topics:

- Understanding Port Security, page 19-4
- Default Port Security Configuration, page 19-6
- Port Security Configuration Guidelines, page 19-6
- Enabling and Configuring Port Security, page 19-7
- Enabling and Configuring Port Security Aging, page 19-9

Understanding Port Security

This section includes information about:

- Secure MAC Addresses, page 19-4
- Security Violations, page 19-5

Secure MAC Addresses

A secure port can have from 1 to 132 associated secure addresses. The total number of available secure addresses on the switch is 1024.

You can configure these types of secure MAC addresses:

- Static secure MAC addresses—These are manually configured by using the **switchport port-security mac-address** *mac-address* interface configuration command, stored in the address table, and added to the switch running configuration.
- Dynamic secure MAC addresses—These are dynamically learned, stored only in the address table, and removed when the switch restarts.

- *Sticky* secure MAC addresses—These can be dynamically learned or manually configured, stored in the address table, and added to the running configuration. If these addresses are saved in the configuration file, when the switch restarts, the interface does not need to dynamically relearn them. Although sticky secure addresses can be manually configured, it is not recommended.

You can configure an interface to convert the dynamic MAC addresses to sticky secure MAC addresses and to add them to the running configuration by enabling *sticky learning*. To enable sticky learning, enter the **switchport port-security mac-address sticky** interface configuration command. When you enter this command, the interface converts all the dynamic secure MAC addresses, including those that were dynamically learned before sticky learning was enabled, to sticky secure MAC addresses.

The sticky secure MAC addresses do not automatically become part of the configuration file, which is the startup configuration used each time the switch restarts. If you save the sticky secure MAC addresses in the configuration file, when the switch restarts, the interface does not need to relearn these addresses. If you do not save the configuration, they are lost.

If sticky learning is disabled, the sticky secure MAC addresses are converted to dynamic secure addresses and are removed from the running configuration.

Security Violations

It is a security violation when one of these situations occurs:

- The maximum number of secure MAC addresses have been added to the address table, and a station whose MAC address is not in the address table attempts to access the interface.
- An address learned or configured on one secure interface is seen on another secure interface in the same VLAN.

You can configure the interface for one of three violation modes, based on the action to be taken if a violation occurs:

- protect—When the number of secure MAC addresses reaches the limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses or increase the number of maximum allowable addresses. You are not notified that a security violation has occurred.
- restrict—When the number of secure MAC addresses reaches the limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses or increase the number of maximum allowable addresses. In this mode, you are notified that a security violation has occurred. Specifically, an SNMP trap is sent, a syslog message is logged, and the violation counter increments.
- shutdown—In this mode, a port security violation causes the interface to immediately become error-disabled, and turns off the port LED. It also sends an SNMP trap, logs a syslog message, and increments the violation counter. When a secure port is in the error-disabled state, you can bring it out of this state by entering the **errdisable recovery cause** *psecure-violation* global configuration command, or you can manually re-enable it by entering the **shutdown** and **no shutdown** interface configuration commands. This is the default mode.

Table 19-1 shows the the violation mode and the actions taken when you configure an interface for port security.

Table 19-1 Security Violation Mode Actions

Violation Mode	Traffic is forwarded[1]	Sends SNMP trap	Sends syslog message	Displays error message[2]	Violation counter increments	Shuts down port
protect	No	No	No	No	No	No
restrict	No	Yes	Yes	No	Yes	No
shutdown	No	Yes	Yes	No	Yes	Yes

1. Packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses.
2. The switch will return an error message if you manually configure an address that would cause a security violation.

Default Port Security Configuration

Table 19-2 shows the default port security configuration for an interface.

Table 19-2 Default Port Security Configuration

Feature	Default Setting
Port security	Disabled on a port
Maximum number of secure MAC addresses	One
Violation mode	Shutdown

Port Security Configuration Guidelines

Follow these guidelines when configuring port security:

- Port security can only be configured on static access ports.
- A secure port cannot be a dynamic access port or a trunk port.
- A secure port cannot be a destination port for Switched Port Analyzer (SPAN).
- A secure port cannot belong to a Fast EtherChannel or Gigabit EtherChannel port group.
- You cannot configure static secure or sticky secure MAC addresses on a voice VLAN.
- When you enable port security on an interface that is also configured with a voice VLAN, you must set the maximum allowed secure addresses on the port to at least two. If any type of port security is enabled on the access VLAN, dynamic port security is automatically enabled on the voice VLAN. You cannot configure port security on a per-VLAN basis.
- To enable port security on an 802.1X port, you must first enable the 802.1X multiple-hosts mode on the port (for switches running the enhanced software image [EI]).
- The switch does not support port security aging of sticky secure MAC addresses.

Enabling and Configuring Port Security

Beginning in privileged EXEC mode, follow these steps to restrict input to an interface by limiting and identifying MAC addresses of the stations allowed to access the port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the type and number of the physical interface to configure, for example **gigabitethernet0/1**, and enter interface configuration mode.
Step 3	**switchport mode access**	Set the interface mode as access; an interface in the default mode (dynamic desirable) cannot be configured as a secure port.
Step 4	**switchport port-security**	Enable port security on the interface.
Step 5	**switchport port-security maximum** *value*	(Optional) Set the maximum number of secure MAC addresses for the interface. The range is 1 to 132; the default is 1.
Step 6	**switchport port-security violation** {**protect** | **restrict** | **shutdown**}	(Optional) Set the violation mode, the action to be taken when a security violation is detected, as one of these: • **protect**—When the number of secure MAC addresses reaches the limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses or increase the number of maximum allowable addresses. You are not notified that a security violation has occurred. • **restrict**—When the number of secure MAC addresses reaches the limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses or increase the number of maximum allowable addresses. In this mode, you are notified that a security violation has occurred. Specifically, an SNMP trap is sent, a syslog message is logged, and the violation counter increments. • **shutdown**—In this mode, a port security violation causes the interface to immediately become error-disabled, and turns off the port LED. It also sends an SNMP trap, logs a syslog message, and increments the violation counter. **Note** When a secure port is in the error-disabled state, you can bring it out of this state by entering the **errdisable recovery cause** *psecure-violation* global configuration command, or you can manually re-enable it by entering the **shutdown** and **no shutdown** interface configuration commands.
Step 7	**switchport port-security mac-address** *mac-address*	(Optional) Enter a static secure MAC address for the interface, repeating the command as many times as necessary. You can use this command to enter the maximum number of secure MAC addresses. If you configure fewer secure MAC addresses than the maximum, the remaining MAC addresses are dynamically learned. **Note** If you enable sticky learning after you enter this command, the secure addresses that were dynamically learned are converted to sticky secure MAC addresses and are added to the running configuration.

	Command	Purpose
Step 8	**switchport port-security mac-address sticky**	(Optional) Enable sticky learning on the interface.
Step 9	**end**	Return to privileged EXEC mode.
Step 10	**show port-security** **show port-security address** **show port-security interface** *interface-id*	Verify your entries.
Step 11	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return the interface to the default condition as not a secure port, use the **no switchport port-security** interface configuration command. If you enter this command when sticky learning is enabled, the sticky secure addresses remain part of the running configuration but are removed from the address table. All addresses are now dynamically learned.

To return the interface to the default number of secure MAC addresses, use the **no switchport port-security maximum** *value* interface configuration command.

To return the violation mode to the default condition (shutdown mode), use the **no switchport port-security violation** {**protocol** | **restrict**} interface configuration command.

To disable sticky learning on an interface, use the **no switchport port-security mac-address sticky** interface configuration command. The interface converts the sticky secure MAC addresses to dynamic secure addresses.

To delete a static secure MAC address from the address table, use the **no switchport port-security mac-address** *mac-address* interface configuration command.

To delete a dynamic secure MAC address from the address table, use the **clear port-security dynamic address** *mac-addr* privileged EXEC command. To delete all the dynamic addresses on an interface, use the **clear port-security dynamic interface** *interface-id* privileged EXEC command.

To delete a sticky secure MAC addresses from the address table, use the **clear port-security sticky** *mac-addr* privileged EXEC command. To delete all the sticky addresses on an interface, use the **clear port-security sticky** *interface-id* privileged EXEC command.

This example shows how to enable port security on Fast Ethernet port 1 and to set the maximum number of secure addresses to 50. The violation mode is the default, no static secure MAC addresses are configured, and sticky learning is enabled.

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# interface fastethernet0/1
Switch(config-if)# switchport mode access
Switch(config-if)# switchport port-security
Switch(config-if)# switchport port-security maximum 50
Switch(config-if)# switchport port-security mac-address sticky
Switch(config-if)# end
Switch# show port-security interface fastethernet0/1
Port Security: Enabled
Port status: SecureUp
Violation mode: Shutdown
Maximum MAC Addresses :50
Total MAC Addresses: 11
Configured MAC Addresses: 0
Sticky MAC Addresses :11
Aging time: 20 mins
Aging type: Inactivity
```

```
SecureStatic address aging: Enabled
Security Violation count: 0
```

This example shows how to configure a static secure MAC address and a sticky secure MAC address on Fast Ethernet port 12 and verify the configuration:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# interface fastethernet0/12
Switch(config-if)# switchport mode access
Switch(config-if)# switchport port-security
Switch(config-if)# switchport port-security mac-address 0000.02000.0004
Switch(config-if)# switchport port-security mac-address sticky
Switch(config-if)# switchport port-security mac-address sticky 0008.a343.b581
Switch(config-if)# end
Switch# show port-security address
=          Secure Mac Address Table
------------------------------------------------------------------
Vlan    Mac Address       Type                Ports   Remaining Age
                                                         (mins)
----    -----------       ----                -----   -------------
   1    0000.0000.000a    SecureDynamic       Fa0/1      -
   1    0000.0002.0300    SecureDynamic       Fa0/1      -
   1    0000.0200.0003    SecureConfigured    Fa0/1      -
   1    0000.0200.0004    SecureConfigured    Fa0/12     -
   1    0003.fd62.1d40    SecureConfigured    Fa0/5      -
   1    0003.fd62.1d45    SecureConfigured    Fa0/5      -
   1    0003.fd62.21d3    SecureSticky        Fa0/5      -
   1    0005.7428.1a45    SecureSticky        Fa0/8      -
   1    0005.7428.1a46    SecureSticky        Fa0/8      -
   1    0006.1218.2436    SecureSticky        Fa0/8      -
   1    0008.a343.b581    SecureSticky        Fa0/12     -
------------------------------------------------------------------
Total Addresses in System :11
Max Addresses limit in System :1024
```

Enabling and Configuring Port Security Aging

You can use port security aging to set the aging time for static and dynamic secure addresses on a port. Two types of aging are supported per port:

- Absolute—The secure addresses on the port are deleted after the specified aging time.
- Inactivity—The secure addresses on the port are deleted only if the secure addresses are inactive for the specified aging time.

Use this feature to remove and add PCs on a secure port without manually deleting the existing secure MAC addresses and to still limit the number of secure addresses on a port. You can enable or disable the aging of statically-configured secure addresses on a per-port basis.

Beginning in privileged EXEC mode, follow these steps to configure port security aging:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the port on which you want to enable port security aging, and enter interface configuration mode. **Note** The switch does not support port security aging of sticky secure addresses.
Step 3	**switchport port-security aging** {**static** | **time** *time* | **type** {**absolute** | **inactivity**}}	Enable or disable static aging for the secure port, or set the aging time or type. Enter **static** to enable aging for statically configured secure addresses on this port. For *time*, specify the aging time for this port. The valid range is from 0 to 1440 minutes. If the time is equal to 0, aging is disabled for this port. For **type**, select one of these keywords: • **absolute**—Sets the aging type as absolute aging. All the secure addresses on this port age out exactly after the time *(*minutes) specified lapses and are removed from the secure address list. • **inactivity**—Sets the aging type as inactivity aging. The secure addresses on this port age out only if there is no data traffic from the secure source addresses for the specified time period.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show port-security** [**interface** *interface-id*] [**address**]	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable port security aging for all secure addresses on a port, use the **no switchport port-security aging time** interface configuration command. To disable aging for only statically configured secure addresses, use the **no switchport port-security aging static** interface configuration command.

This example shows how to set the aging time as 2 hours for the secure addresses on the Fast Ethernet interface 0/1:

```
Switch(config)# interface fastethernet0/1
Switch(config-if)# switchport port-security aging time 120
```

This example shows how to set the aging time as 2 minutes for the inactivity aging type with aging enabled for the configured secure addresses on the interface:

```
Switch(config-if)# switchport port-security aging time 2
Switch(config-if)# switchport port-security aging type inactivity
Switch(config-if)# switchport port-security aging static
```

You can verify the previous commands by entering the **show port-security interface** *interface-id* privileged EXEC command.

Displaying Port-Based Traffic Control Settings

The **show interfaces** *interface-id* **switchport** privileged EXEC command displays (among other characteristics) the interface traffic suppression and control configuration. The **show interfaces counters** privileged EXEC commands display the count of discarded packets. The **show storm-control** and **show port-security** privileged EXEC commands display those features.

To display traffic control information, use one or more of the privileged EXEC commands in Table 19-3.

Table 19-3 Commands for Displaying Traffic Control Status and Configuration

Command	Purpose
show interfaces [*interface-id*] **switchport**	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port protection settings.
show storm-control [*interface-id*] [**broadcast** | **multicast** | **unicast**]	Displays storm control suppression levels set on all interfaces or the specified interface for the specified traffic type or for broadcast traffic if no traffic type is entered.
show interfaces [*interface-id*] **counters broadcast**	Displays the storm-control broadcast suppression discard counter with the number of packets discarded for all interfaces or the specified interface.
show interfaces [*interface-id*] **counters multicast**	Displays the storm-control multicast suppression discard counter with the number of packets discarded for all interfaces or the specified interface.
show interfaces [*interface-id*] **counters unicast**	Displays the storm-control unicast suppression discard counter with the number of packets discarded for all interfaces or the specified interface.
show port-security [**interface** *interface-id*]	Displays port security settings for the switch or for the specified interface, including the maximum allowed number of secure MAC addresses for each interface, the number of secure MAC addresses on the interface, the number of security violations that have occurred, and the violation mode.
show port-security [**interface** *interface-id*] **address**	Displays all secure MAC addresses configured on all switch interfaces or on a specified interface with aging information for each address.

CHAPTER 20

Configuring UDLD

This chapter describes how to configure the UniDirectional Link Detection (UDLD) protocol on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

- Understanding UDLD, page 20-1
- Configuring UDLD, page 20-3
- Displaying UDLD Status, page 20-6

Understanding UDLD

UDLD is a Layer 2 protocol that enables devices connected through fiber-optic or twisted-pair Ethernet cables to monitor the physical configuration of the cables and detect when a unidirectional link exists. All connected devices must support UDLD for the protocol to successfully identify and disable unidirectional links. When UDLD detects a unidirectional link, it administratively shuts down the affected port and alerts you. Unidirectional links can cause a variety of problems, including spanning-tree topology loops.

UDLD works with the Layer 1 mechanisms to determine the physical status of a link. At Layer 1, autonegotiation takes care of physical signaling and fault detection. UDLD performs tasks that autonegotiation cannot perform, such as detecting the identities of neighbors and shutting down misconnected interfaces. When you enable both autonegotiation and UDLD, Layer 1 and Layer 2 detections work together to prevent physical and logical unidirectional connections and the malfunctioning of other protocols.

A unidirectional link occurs whenever traffic sent by the local device is received by the neighbor but traffic from the neighbor is not received by the local device. If one of the fiber strands in a pair is disconnected, as long as autonegotiation is active, the link does not stay up. In this case, the logical link is undetermined, and UDLD does not take any action. If both fibers are working normally from a Layer 1 perspective, UDLD at Layer 2 determines whether those fibers are connected correctly and whether traffic is flowing bidirectionally between the correct neighbors. This check cannot be performed by autonegotiation because autonegotiation operates at Layer 1.

UDLD operates by using two mechanisms:

- Neighbor database maintenance

  UDLD learns about other UDLD-capable neighbors by periodically sending a hello packet (also called an advertisement or probe) on every active interface to keep each device informed about its neighbors.

  When the switch receives a hello message, it caches the information until the age time (hold time or time-to-live) expires. If the switch receives a new hello message before an older cache entry ages, the switch replaces the older entry with the new one.

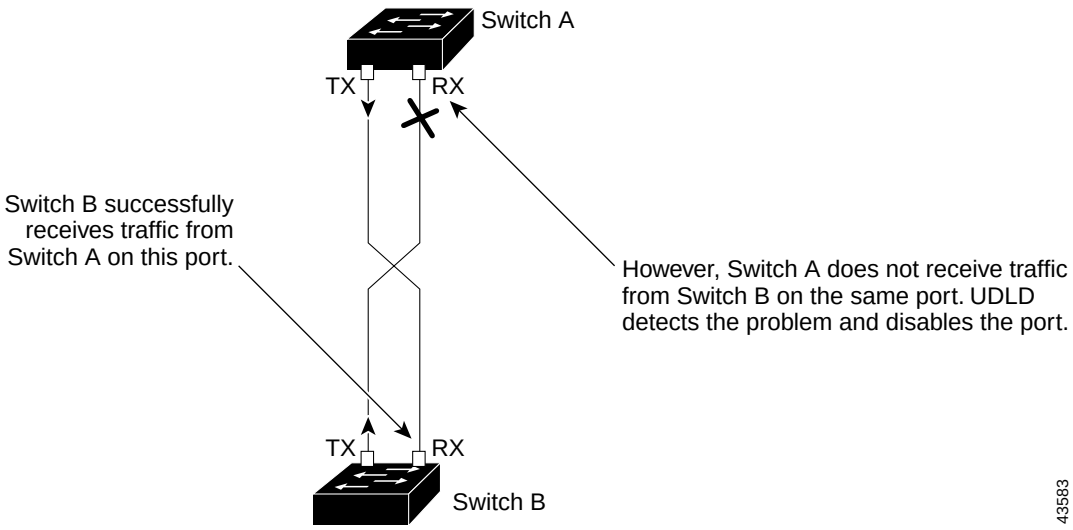
  Whenever an interface is disabled and UDLD is running, whenever UDLD is disabled on an interface, or whenever the switch is reset, UDLD clears all existing cache entries for the interfaces affected by the configuration change. UDLD sends at least one message to inform the neighbors to flush the part of their caches affected by the status change. The message is intended to keep the caches synchronized.

- Event-driven detection and echoing

  UDLD relies on echoing as its detection mechanism. Whenever a UDLD device learns about a new neighbor or receives a resynchronization request from an out-of-sync neighbor, it restarts the detection window on its side of the connection and sends echo messages in reply. Because this behavior is the same on all UDLD neighbors, the sender of the echoes expects to receive an echo in reply. If the detection window ends and no valid reply message is received, the link is considered unidirectional, and the interface is shut down.

Figure 20-1 shows an example of a unidirectional link condition.

Figure 20-1 UDLD Detection of a Unidirectional Link


Switch A
TX
RX
Switch B successfully receives traffic from Switch A on this port.
However, Switch A does not receive traffic from Switch B on the same port. UDLD detects the problem and disables the port.
TX
RX
Switch B
43583

Configuring UDLD

This section describes how to configure UDLD on your switch. It contains this configuration information:

- Default UDLD Configuration, page 20-3
- Enabling UDLD Globally, page 20-4
- Enabling UDLD on an Interface, page 20-4
- Resetting an Interface Shut Down by UDLD, page 20-5

Default UDLD Configuration

Table 20-1 shows the default UDLD configuration.

Table 20-1 Default UDLD Configuration

Feature	Default Setting
UDLD global enable state	Globally disabled
UDLD per-interface enable state for fiber-optic media	Disabled on all Ethernet fiber-optic interfaces
UDLD per-interface enable state for twisted-pair (copper) media	Disabled on all Ethernet 10/100 and 1000BASE-TX interfaces
UDLD aggressive mode	Disabled

A UDLD-capable interface also cannot detect a unidirectional link if it is connected to a UDLD-incapable port of another switch.

Enabling UDLD Globally

Beginning in privileged EXEC mode, follow these steps to enable UDLD in the aggressive or normal mode and to set the configurable message timer on all fiber-optic interfaces on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**udld** {**aggressive** | **enable** | **message time** *message-timer-interval*}	Specify the UDLD mode of operation: • **aggressive**—Enables UDLD in aggressive mode on all fiber-optic interfaces. For details on the usage guidelines for the aggressive mode, refer to the command reference guide. • **enable**—Enables UDLD in normal mode on all fiber-optic interfaces on the switch. UDLD is disabled by default. An individual interface configuration overrides the setting of the **udld enable** global configuration command. • **message time** *message-timer-interval*—Configures the period of time between UDLD probe messages on ports that are in the advertisement phase and are determined to be bidirectional. The range is from 7 to 90 seconds. **Note** This command affects fiber-optic interfaces only. Use the **udld** interface configuration command to enable UDLD on other interface types. For more information, see the "Enabling UDLD on an Interface" section on page 20-4.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show udld**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable UDLD globally, use the **no udld enable** global configuration command to disable normal mode UDLD on all fiber-optic ports. Use the **no udld aggressive** global configuration command to disable aggressive mode UDLD on all fiber-optic ports.

Enabling UDLD on an Interface

Beginning in privileged EXEC mode, follow these steps to enable UDLD in the aggressive or normal mode on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to be enabled for UDLD.

	Command	Purpose
Step 3	**udld** {**aggressive** | **enable**}	Specify the UDLD mode of operation: • **aggressive**—Enables UDLD in aggressive mode on the specified interface. For details on the usage guidelines for the aggressive mode, refer to the command reference for this release. • **enable**—Enables UDLD in normal mode on the specified interface. UDLD is disabled by default. On a fiber-optic interface, this command overrides the **udld enable** global configuration command setting.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show udld** *interface-id*	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable UDLD on a non-fiber-optic interface, use the **no udld enable** interface configuration command.

Note On fiber-optic interfaces, the **no udld enable** command reverts the interface configuration to the **udld enable** global configuration command setting.

To disable UDLD on a fiber-optic interface, use the **udld disable** command to revert to the **udld enable** global configuration command setting. This command is not supported on non-fiber-optic interfaces.

Resetting an Interface Shut Down by UDLD

Beginning in privileged EXEC mode, follow these steps to reset all interfaces shut down by UDLD:

	Command	Purpose
Step 1	**udld reset**	Reset all interfaces shut down by UDLD.
Step 2	**show udld**	Verify your entries.
Step 3	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

You can also bring up the interface by using these commands:

- The **shutdown** interface configuration command followed by the **no shutdown** interface configuration command restarts the disabled interface.
- The **no udld enable** global configuration command re-enables UDLD globally.
- The **udld disable** interface configuration command re-enables UDLD on the specified interface.

Displaying UDLD Status

To display the UDLD status for the specified interface or for all interfaces, use the **show udld** [*interface-id*] privileged EXEC command.

For detailed information about the fields in the display, refer to the command reference for this release.

Configuring CDP

This chapter describes how to configure Cisco Discovery Protocol (CDP) on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release and the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

This chapter consists of these sections:

- Understanding CDP, page 21-1
- Configuring CDP, page 21-2
- Monitoring and Maintaining CDP, page 21-5

Understanding CDP

CDP is a device discovery protocol that runs over Layer 2 (the data link layer) on all Cisco-manufactured devices (routers, bridges, access servers, and switches) and allows network management applications to discover Cisco devices that are neighbors of already known devices. With CDP, network management applications can learn the device type and the Simple Network Management Protocol (SNMP) agent address of neighboring devices running lower-layer, transparent protocols. This feature enables applications to send SNMP queries to neighboring devices.

CDP runs on all media that support Subnetwork Access Protocol (SNAP). Because CDP runs over the data-link layer only, two systems that support different network-layer protocols can learn about each other.

Each CDP-configured device sends periodic messages to a multicast address, advertising at least one address at which it can receive SNMP messages. The advertisements also contain time-to-live, or holdtime information, which is the length of time a receiving device holds CDP information before discarding it. Each device also listens to the messages sent by other devices to learn about neighboring devices.

On the switch, CDP enables the Cluster Management Suite to display a graphical view of the network. The switch uses CDP to find cluster candidates and maintain information about cluster members and other devices up to three cluster-enabled devices away from the command switch by default.

The switch supports CDP version 2.

Configuring CDP

These sections include CDP configuration information and procedures:

- Default CDP Configuration, page 21-2
- Configuring the CDP Characteristics, page 21-2
- Disabling and Enabling CDP, page 21-3
- Disabling and Enabling CDP on an Interface, page 21-4

Default CDP Configuration

Table 21-1 shows the default CDP configuration.

Table 21-1 Default CDP Configuration

Feature	Default Setting
CDP global state	Enabled
CDP interface state	Enabled
CDP timer (packet update frequency)	60 seconds
CDP holdtime (before discarding)	180 seconds
CDP version-2 advertisements	Enabled

Configuring the CDP Characteristics

You can configure the frequency of CDP updates, the amount of time to hold the information before discarding it, and whether or not to send version-2 advertisements.

Beginning in privileged EXEC mode, follow these steps to configure the CDP timer, holdtime, and advertisement type.

Note Steps 2 through 4 are all optional and can be performed in any order.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**cdp timer** *seconds*	(Optional) Set the transmission frequency of CDP updates in seconds. The range is from 5 to 254; the default is 60 seconds.
Step 3	**cdp holdtime** *seconds*	(Optional) Specify the amount of time a receiving device should hold the information sent by your device before discarding it. The range is from 10 to 255 seconds; the default is 180 seconds.
Step 4	**cdp advertise-v2**	(Optional) Configure CDP to send version-2 advertisements. This is the default state.
Step 5	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 6	**show cdp**	Verify configuration by displaying global information about CDP on the device.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no** form of the CDP commands to return to the default settings.

This example shows how to configure and verify CDP characteristics.

```
Switch# configure terminal
Switch(config)# cdp timer 50
Switch(config)# cdp holdtime 120
Switch(config)# cdp advertise-v2
Switch(config)# end

Switch# show cdp
Global CDP information:
        Sending CDP packets every 50 seconds
        Sending a holdtime value of 120 seconds
        Sending CDPv2 advertisements is enabled
```

For additional CDP **show** commands, see the "Monitoring and Maintaining CDP" section on page 21-5.

Disabling and Enabling CDP

CDP is enabled by default.

Note Creating and maintaining switch clusters is based on the regular exchange of CDP messages. Disabling CDP can interrupt cluster discovery. For more information, see Chapter 7, "Clustering Switches."

Beginning in privileged EXEC mode, follow these steps to disable the CDP device discovery capability:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no cdp run**	Disable CDP.
Step 3	**end**	Return to privileged EXEC mode.

Beginning in privileged EXEC mode, follow these steps to enable CDP when it has been disabled:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**cdp run**	Enable CDP after disabling it.
Step 3	**end**	Return to privileged EXEC mode.

This example shows how to enable CDP if it has been disabled.

```
Switch# configure terminal
Switch(config)# cdp run
Switch(config)# end
```

Disabling and Enabling CDP on an Interface

CDP is enabled by default on all supported interfaces to send and receive CDP information.

Beginning in privileged EXEC mode, follow these steps to disable CDP on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and enter the interface on which you are disabling CDP.
Step 3	**no cdp enable**	Disable CDP on an interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Beginning in privileged EXEC mode, follow these steps to enable CDP on an interface when it has been disabled:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and enter the interface on which you are enabling CDP.
Step 3	**cdp enable**	Enable CDP on an interface after disabling it.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to enable CDP on an interface when it has been disabled.

```
Switch# configure terminal
Switch(config)# interface fastethernet0/5
Switch(config-if)# cdp enable
Switch(config-if)# end
```

Monitoring and Maintaining CDP

To monitor and maintain CDP on your device, perform one or more of these tasks, beginning in privileged EXEC mode.

Command	Description
clear cdp counters	Reset the traffic counters to zero.
clear cdp table	Delete the CDP table of information about neighbors.
show cdp	Display global information, such as frequency of transmissions and the holdtime for packets being sent.
show cdp entry *entry-name* [**protocol** | **version**]	Display information about a specific neighbor. You can enter an asterisk (*) to display all CDP neighbors, or you can enter the name of the neighbor about which you want information. You can also limit the display to information about the protocols enabled on the specified neighbor or information about the version of software running on the device.
show cdp interface [*type number*]	Display information about interfaces where CDP is enabled. You can limit the display to the type of interface or the number of the interface about which you want information (for example, entering **gigabitethernet 0/1** displays information only about Gigabit Ethernet port 1).
show cdp neighbors [*type number*] [**detail**]	Display information about neighbors, including device type, interface type and number, holdtime settings, capabilities, platform, and port ID. You can limit the display to neighbors on a specific type or number of interface or expand the display to provide more detailed information.
show cdp traffic	Display CDP counters, including the number of packets sent and received and checksum errors.

This is an example of the output from the **show cdp** privileged EXEC commands:

```
Switch# show cdp
Global CDP information:
        Sending CDP packets every 50 seconds
        Sending a holdtime value of 120 seconds
        Sending CDPv2 advertisements is enabled
```

CHAPTER 22

Configuring SPAN and RSPAN

This chapter describes how to configure Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

This chapter consists of these sections:

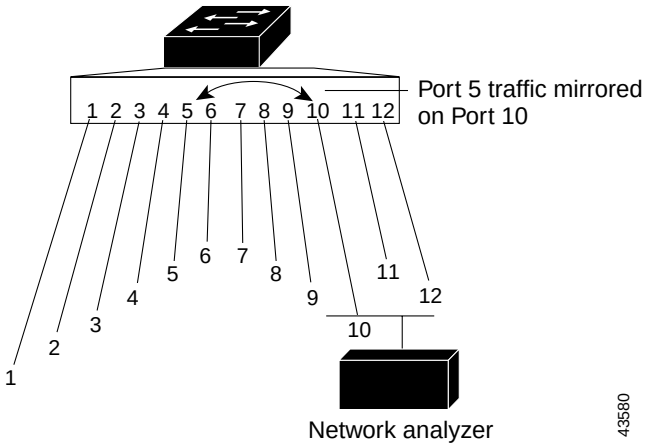
- Understanding SPAN and RSPAN, page 22-1
- Configuring SPAN, page 22-7
- Configuring RSPAN, page 22-12
- Displaying SPAN and RSPAN Status, page 22-16

Understanding SPAN and RSPAN

You can analyze network traffic passing through ports by using SPAN to send a copy of the traffic to another port on the switch that has been connected to a SwitchProbe device or other Remote Monitoring (RMON) probe or security device. SPAN mirrors received or transmitted (or both) traffic on one or more source ports to a destination port for analysis.

For example, in Figure 22-1, all traffic on port 5 (the source port) is mirrored to port 10 (the destination port). A network analyzer on port 10 receives all network traffic from port 5 without being physically attached to port 5.

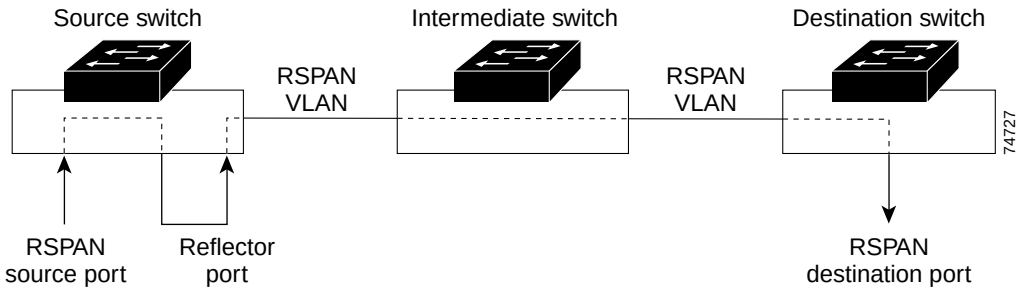
Figure 22-1 Example SPAN Configuration



Only traffic that enters or leaves source ports can be monitored by using SPAN.

RSPAN extends SPAN by enabling remote monitoring of multiple switches across your network. The traffic for each RSPAN session is carried over a user-specified RSPAN VLAN that is dedicated for that RSPAN session in all participating switches. The SPAN traffic from the sources is copied onto the RSPAN VLAN through a reflector port and then forwarded over trunk ports that are carrying the RSPAN VLAN to any RSPAN destination session monitoring the RSPAN VLAN, as shown in Figure 22-2.

Figure 22-2 Example of RSPAN Configuration



SPAN and RSPAN do not affect the switching of network traffic on source ports; a copy of the packets received or sent by the source interfaces are sent to the destination interface. Except for traffic that is required for the SPAN or RSPAN session, reflector ports and destination ports do not receive or forward traffic.

You can use the SPAN destination port to inject traffic from a network security device. For example, if you connect a Cisco Intrusion Detection System (IDS) Sensor Appliance to a destination port, the IDS device can send TCP Reset packets to close down the TCP session of a suspected attacker.

Note You cannot use the RSPAN destination port to inject traffic from a network security device. The switch does not support ingress forwarding on an RSPAN destination port.

SPAN and RSPAN Concepts and Terminology

This section describes concepts and terminology associated with SPAN and RSPAN configuration.

SPAN Session

A local SPAN session is an association of a destination port with source ports. You can monitor incoming or outgoing traffic on a series or range of ports.

An RSPAN session is an association of source ports across your network with an RSPAN VLAN. The destination source is the RSPAN VLAN.

SPAN sessions do not interfere with the normal operation of the switch. However, an oversubscribed SPAN destination, for example, a 10-Mbps port monitoring a 100-Mbps port, results in dropped or lost packets.

You can configure SPAN sessions on disabled ports; however, a SPAN session does not become active unless you enable the destination port and at least one source port for that session. The **show monitor session** *session_number* privileged EXEC command displays the operational status of a SPAN session.

A SPAN session remains inactive after system power-on until the destination port is operational.

Traffic Types

SPAN sessions include these traffic types:

- Receive (Rx) SPAN—The goal of receive (or ingress) SPAN is to monitor as much as possible all the packets received by the source interface. A copy of each packet received by the source is sent to the destination port for that SPAN session. You can monitor a series or range of ingress ports in a SPAN session.

  At the destination port, if tagging is enabled, the packets appear with the 802.1Q header. If no tagging is specified, packets appear in the native format.

  Packets that are modified because of quality of service (QoS)—for example, modified Differentiated Services Code Point (DSCP)—are copied with modification for Rx SPAN.

- Transmit (Tx) SPAN—The goal of transmit (or egress) SPAN is to monitor as much as possible all the packets sent by the source interface after all modification and processing is performed by the switch. A copy of each packet sent by the source is sent to the destination port for that SPAN session. The copy is provided after the packet is modified. You can monitor a range of egress ports in a SPAN session.

  Packets that are modified because of QoS, the modified packet might not have the same DSCP (IP packet) or CoS (non-IP packet) as the SPAN source.

  Some features that can cause a packet to be dropped during transmit processing might also affect the duplicated copy for SPAN. These features include IP standard and extended output ACLs on multicast packets, and egress QoS policing. In the case of output ACLs, if the SPAN source drops the packet, the SPAN destination would also drop the packet. If the source port is oversubscribed, the destination ports will have different dropping behavior.

- Both—In a SPAN session, you can monitor a series or range of ports for both received and sent packets.

Source Port

A source port (also called a *monitored port*) is a switched port that you monitor for network traffic analysis. In a single local SPAN session or RSPAN source session, you can monitor source port traffic such as received (Rx), transmitted (Tx), or bidirectional (both). The switch supports any number of source ports (up to the maximum number of available ports on the switch).

A source port has these characteristics:

- It can be any port type (for example, EtherChannel, Fast Ethernet, Gigabit Ethernet, and so forth).
- It cannot be a destination port.
- Each source port can be configured with a direction (ingress, egress, or both) to monitor. For EtherChannel sources, the monitored direction would apply to all the physical ports in the group.
- Source ports can be in the same or different VLANs.

You can configure a trunk port as a source port. All VLANs active on the trunk are monitored.

Destination Port

Each local SPAN session or RSPAN destination session must have a destination port (also called a *monitoring port*) that receives a copy of traffic from the source port.

The destination port has these characteristics:

- It must reside on the same switch as the source port (for a local SPAN session).
- It can be any Ethernet physical port.
- It cannot be a source port or a reflector port.
- It cannot be an EtherChannel group or a VLAN.
- It can be a physical port that is assigned to an EtherChannel group, even if the EtherChannel group has been specified as a SPAN source. The port is removed from the group while it is configured as a SPAN destination port.
- The port does not transmit any traffic except that required for the SPAN session.
- If ingress traffic forwarding is enabled for a network security device, the destination port forwards traffic at Layer 2.
- It does not participate in spanning tree while the SPAN session is active.
- When it is a destination port, it does not participate in any of the Layer 2 protocols (STP, VTP, CDP, DTP, PagP, LACP).
- No address learning occurs on the destination port.
- A destination port receives copies of sent and received traffic for all monitored source ports. If a destination port is oversubscribed, it could become congested. This could affect traffic forwarding on one or more of the source ports.

Reflector Port

The reflector port is the mechanism that copies packets onto an RSPAN VLAN. The reflector port forwards only the traffic from the RSPAN source session with which it is affiliated. Any device connected to a port set as a reflector port loses connectivity until the RSPAN source session is disabled.

The reflector port has these characteristics:

- It is a port set to loopback.
- It cannot be an EtherChannel group, it does not trunk, and it cannot do protocol filtering.
- It can be a physical port that is assigned to an EtherChannel group, even if the EtherChannel group is specified as a SPAN source. The port is removed from the group while it is configured as a reflector port.
- A port used as a reflector port cannot be a SPAN source or destination port, nor can a port be a reflector port for more than one session at a time.
- It is invisible to all VLANs.
- The native VLAN for looped-back traffic on a reflector port is the RSPAN VLAN.
- The reflector port loops back untagged traffic to the switch. The traffic is then placed on the RSPAN VLAN and flooded to any trunk ports that carry the RSPAN VLAN.
- Spanning tree is automatically disabled on a reflector port.
- A reflector port receives copies of sent and received traffic for all monitored source ports. If a reflector port is oversubscribed, it could become congested. This could affect traffic forwarding on one or more of the source ports.

If the bandwidth of the reflector port is not sufficient for the traffic volume from the corresponding source ports, the excess packets are dropped. A 10/100 port reflects at 100 Mbps. A Gigabit port reflects at 1 Gbps.

SPAN Traffic

You can use local SPAN to monitor all network traffic, including multicast and bridge protocol data unit (BPDU) packets, and Cisco Discovery Protocol (CDP), VLAN Trunk Protocol (VTP), Dynamic Trunking Protocol (DTP), Spanning Tree Protocol (STP), Port Aggregation Protocol (PagP), and Link Aggregation Control Protocol (LACP) packets. You cannot use RSPAN to monitor Layer 2 protocols. See the "RSPAN Configuration Guidelines" section on page 22-12 for more information.

In some SPAN configurations, multiple copies of the same source packet are sent to the SPAN destination port. For example, a bidirectional (both Rx and Tx) SPAN session is configured for the sources a1 Rx monitor and the a2 Rx and Tx monitor to destination port d1. If a packet enters the switch through a1 and is switched to a2, both incoming and outgoing packets are sent to destination port d1.

SPAN and RSPAN Interaction with Other Features

SPAN interacts with these features:

- Spanning Tree Protocol (STP)—A destination port or a reflector port does not participate in STP while its SPAN or RSPAN session is active. The destination or reflector port can participate in STP after the SPAN or RSPAN session is disabled. On a source port, SPAN does not affect the STP status. STP can be active on trunk ports carrying an RSPAN VLAN.
- Cisco Discovery Protocol (CDP)—A SPAN destination port does not participate in CDP while the SPAN session is active. After the SPAN session is disabled, the port again participates in CDP.
- VLAN Trunking Protocol (VTP)—You can use VTP to prune an RSPAN VLAN between switches.
- VLAN and trunking—You can modify VLAN membership or trunk settings for source, destination, or reflector ports at any time. However, changes in VLAN membership or trunk settings for a destination or reflector port do not take effect until you disable the SPAN or RSPAN session. Changes in VLAN membership or trunk settings for a source port immediately take effect, and the SPAN session automatically adjusts accordingly.
- EtherChannel—You can configure an EtherChannel group as a source port but not as a SPAN destination port. When a group is configured as a SPAN source, the entire group is monitored.

  If a port is added to a monitored EtherChannel group, the new port is added to the SPAN source port list. If a port is removed from a monitored EtherChannel group, it is automatically removed from the source port list. If the port is the only port in the EtherChannel group, the EtherChannel group is removed from SPAN.

  If a physical port that belongs to an EtherChannel group is configured as a SPAN source, destination, or reflector port, it is removed from the group. After the port is removed from the SPAN session, it rejoins the EtherChannel group. Ports removed from an EtherChannel group remain members of the group, but they are in the *down* or *standalone* state.

  If a physical port that belongs to an EtherChannel group is a destination or reflector port and the EtherChannel group is a source, the port is removed from the EtherChannel group and from the list of monitored ports.
- QoS—For ingress monitoring, the packets sent to the SPAN destination port might be different from the packets actually received at the SPAN source port because the packets are forwarded after ingress QoS classification and policing. The packet DSCP might not be the same as the received packet.
- Multicast traffic can be monitored. For egress and ingress port monitoring, only a single unedited packet is sent to the SPAN destination port. It does not reflect the number of times the multicast packet is sent.
- Port security—A secure port cannot be a SPAN destination port.

SPAN and RSPAN Session Limits

You can configure (and store in NVRAM) one local SPAN session or multiple RSPAN sessions on a switch. The number of active sessions and combinations are subject to these restrictions:

- SPAN or RSPAN source (rx, tx, both): 1 active session limit. (SPAN and RSPAN are mutually exclusive on a source switch).
- RSPAN source sessions have one destination per session with an RSPAN VLAN associated for that session.

- Each RSPAN destination session has one or more destination interfaces for each RSPAN VLAN that they support.
- RSPAN destination sessions are limited to two, or one if a local SPAN or a source RSPAN session is configured on the same switch.

Default SPAN and RSPAN Configuration

Table 22-1 shows the default SPAN and RSPAN configuration.

Table 22-1 Default SPAN and RSPAN Configuration

Feature	Default Setting
SPAN state	Disabled.
Source port traffic to monitor	Both received and sent traffic (**both**).
Encapsulation type (destination port)	Native form (no encapsulation type header).
Ingress forwarding (destination port)	Disabled.

Configuring SPAN

This section describes how to configure SPAN on your switch. It contains this configuration information:

- SPAN Configuration Guidelines, page 22-7
- Creating a SPAN Session and Specifying Ports to Monitor, page 22-8
- Creating a SPAN Session and Enabling Ingress Traffic, page 22-9
- Removing Ports from a SPAN Session, page 22-11

SPAN Configuration Guidelines

Follow these guidelines when configuring SPAN:

- SPAN sessions can coexist with RSPAN sessions within the limits described in the "SPAN and RSPAN Session Limits" section on page 22-6.
- The destination port cannot be a source port; a source port cannot be a destination port.
- You can have only one destination port.
- An EtherChannel port can be a SPAN source port; it cannot be a SPAN destination port.
- For SPAN source ports, you can monitor sent and received traffic for a single port or for a series or range of ports.
- When you configure a switch port as a SPAN destination port, it is no longer a normal switch port; only monitored traffic passes through the SPAN destination port.
- You can configure a disabled port to be a source or destination port, but the SPAN function does not start until the destination port and at least one source port is enabled.
- A SPAN destination port never participates in any VLAN spanning tree. SPAN does include BPDUs in the monitored traffic, so any spanning-tree BPDUs received on the SPAN destination port for a SPAN session were copied from the SPAN source ports.

- When SPAN is enabled, configuration changes have these results:
  - If you change the VLAN configuration of a destination port, the change is not effective until SPAN is disabled.
  - If you disable all source ports or the destination port, the SPAN function stops until both a source and the destination port are enabled.

Creating a SPAN Session and Specifying Ports to Monitor

Beginning in privileged EXEC mode, follow these steps to create a SPAN session and specify the source (monitored) and destination (monitoring) ports:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no monitor session** {*session_number* | **all** | **local** | **remote**}	Clear any existing SPAN configuration for the session. For *session_number*, specify 1. Specify **all** to remove all SPAN sessions, **local** to remove all local sessions, or **remote** to remove all remote SPAN sessions.
Step 3	**monitor session** *session_number* **source interface** *interface-id* [**,** | **-**] [**both** | **rx** | **tx**]	Specify the SPAN session and the source port (monitored port). For *session_number*, specify 1. For *interface-id*, specify the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*). (Optional) [**,** | **-**] Specify a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen. (Optional) Specify the direction of traffic to monitor. If you do not specify a traffic direction, the source interface sends both sent and received traffic. • **both**—Monitor both received and sent traffic. • **rx**—Monitor received traffic. • **tx**—Monitor sent traffic.
Step 4	**monitor session** *session_number* **destination interface** *interface-id* [**encapsulation** {**dot1q**}]	Specify the SPAN session and the destination port (monitoring port). For *session_number*, specify 1. For *interface-id*, specify the destination port. Valid interfaces include physical interfaces. (Optional) Specify the encapsulation header for outgoing packets. If not specified, packets are sent in native form. • **dot1q**—Use 802.1Q encapsulation.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show monitor** [**session** *session_number*]	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to set up a SPAN session, session 1, for monitoring source port traffic to a destination port. First, any existing SPAN configuration for session 1 is cleared, and then bidirectional traffic is mirrored from source port 1 to destination port 10.

```
Switch(config)# no monitor session 1
Switch(config)# monitor session 1 source interface fastEthernet0/1
Switch(config)# monitor session 1 destination interface fastEthernet0/10
encapsulation dot1q
Switch(config)# end
```

Creating a SPAN Session and Enabling Ingress Traffic

Beginning in privileged EXEC mode, follow these steps to create a SPAN session, to specify the source and destination ports, and to enable ingress traffic on the destination port for a network security device (such as a Cisco IDS Sensor Appliance):

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no monitor session** {*session_number* | **all** | **local** | **remote**}	Clear any existing SPAN configuration for the session. For *session_number*, specify 1. Specify **all** to remove all SPAN sessions, **local** to remove all local sessions, or **remote** to remove all remote SPAN sessions.
Step 3	**monitor session** *session_number* **source interface** *interface-id* [**,** | **-**] [**both** | **rx** | **tx**]	Specify the SPAN session and the source port (monitored port). For *session_number*, specify 1. For *interface-id*, specify the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*). (Optional) [**,** | **-**] Specify a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen. (Optional) Specify the direction of traffic to monitor. If you do not specify a traffic direction, the source interface sends both sent and received traffic. • **both**—Monitor both received and sent traffic. • **rx**—Monitor received traffic. • **tx**—Monitor sent traffic.

	Command	Purpose
Step 4	**monitor session** *session_number* **destination interface** *interface-id* [**encapsulation** {**dot1q**}] [**ingress vlan** *vlan id*]	Specify the SPAN session, the destination port (monitoring port), the packet encapsulation, and the ingress VLAN. For *session_number*, specify 1. For *interface-id*, specify the destination port. Valid interfaces include physical interfaces. (Optional) Specify the encapsulation header for outgoing packets. If not specified, packets are sent in native form. • **dot1q**—Use 802.1Q encapsulation. (Optional) Enter **ingress vlan** *vlan id* to enable ingress forwarding and specify a default VLAN.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show monitor** [**session** *session_number*]	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to configure the destination port for ingress traffic on VLAN 5 by using a security device that does not support 802.1Q encapsulation.

```
Switch(config)# monitor session 1 destination interface Fa 0/5 ingress vlan 5
```

This example shows how to configure the destination port for ingress traffic on VLAN 5 by using a security device that supports 802.1Q encapsulation.

```
Switch(config)# monitor session 1 destination interface Fa 0/5 encapsulation dot1q ingress
vlan 5
```

This example shows how to disable ingress traffic forwarding on the destination port.

```
Switch(config)# monitor session 1 destination interface Fa 0/5 encapsulation dot1q
```

Removing Ports from a SPAN Session

Beginning in privileged EXEC mode, follow these steps to remove a port as a SPAN source for a session:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no monitor session** *session_number* **source interface** *interface-id* [**,** | **-**] [**both** | **rx** | **tx**]	Specify the characteristics of the source port (monitored port) and SPAN session to remove. For *session*, specify 1. For *interface-id*, specify the source port to no longer monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*). (Optional) Use [**,** | **-**] to specify a series or range of interfaces if they were configured. This option is valid when monitoring only received traffic. Enter a space before and after the comma; enter a space before and after the hyphen. (Optional) Specify the direction of traffic (**both**, **rx**, or **tx**) to no longer monitor. If you do not specify a traffic direction, both transmit and receive are disabled.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show monitor** [**session** *session_number*]	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a source or destination port from the SPAN session, use the **no monitor session** *session_number* **source interface** *interface-id* global configuration command or the **no monitor session** *session_number* **destination interface** *interface-id* global configuration command. To change the encapsulation type back to the default (native), use the **monitor session** *session_number* **destination interface** *interface-id* without the **encapsulation** keyword.

This example shows how to remove port 1 as a SPAN source for SPAN session 1:

```
Switch(config)# no monitor session 1 source interface fastEthernet0/1
Switch(config)# end
```

This example shows how to disable received traffic monitoring on port 1, which was configured for bidirectional monitoring:

```
Switch(config)# no monitor session 1 source interface fastEthernet0/1 rx
```

The monitoring of traffic received on port 1 is disabled, but traffic sent from this port continues to be monitored.

Configuring RSPAN

This section describes how to configure RSPAN on your switch. It contains this configuration information:

- RSPAN Configuration Guidelines, page 22-12
- Creating an RSPAN Session, page 22-13
- Creating an RSPAN Destination Session, page 22-14
- Removing Ports from an RSPAN Session, page 22-15

RSPAN Configuration Guidelines

To use the RSPAN feature described in this section, you must have the EI installed on your switch. Follow these guidelines when configuring RSPAN:

- All the items in the "SPAN Configuration Guidelines" section on page 22-7 apply to RSPAN.

Note As RSPAN VLANs have special properties, you should reserve a few VLANs across your network for use as RSPAN VLANs; do not assign access ports to these VLANs.

- RSPAN sessions can coexist with SPAN sessions within the limits described in the "SPAN and RSPAN Session Limits" section on page 22-6.
- For RSPAN configuration, you can distribute the source ports and the destination ports across multiple switches in your network.
- A port cannot serve as an RSPAN source port or RSPAN destination port while designated as an RSPAN reflector port.
- When you configure a switch port as a reflector port, it is no longer a normal switch port; only looped-back traffic passes through the reflector port.
- RSPAN does not support BPDU packet monitoring or other Layer 2 switch protocols.
- In a network consisting of only Catalyst 2950 or Catalyst 2955 switches, you must use a unique RSPAN VLAN session on each source switch. If more than one source switch uses the same RSPAN VLAN, the switches are limited to act only as source switches to ensure the delivery of all monitored traffic to the destination switch.
- You can configure any VLAN as an RSPAN VLAN as long as these conditions are met:
  - The RSPAN VLAN is not configured as a native VLAN.
  - Extended range RSPAN VLANs will not be propagated to other switches using VTP.
  - No access port is configured in the RSPAN VLAN.
  - All participating switches support RSPAN.

Note The RSPAN VLAN cannot be VLAN 1 (the default VLAN) or VLAN IDs 1002 through 1005 (reserved to Token Ring and FDDI VLANs).

- You should create an RSPAN VLAN before configuring an RSPAN source or destination session.
- If you enable VTP and VTP pruning, RSPAN traffic is pruned in the trunks to prevent the unwanted flooding of RSPAN traffic across the network for VLAN-IDs that are lower than 1005.

Creating an RSPAN Session

First create an RSPAN VLAN that *does not* exist for the RSPAN session in any of the switches that will participate in RSPAN. With VTP enabled in the network, you can create the RSPAN VLAN in one switch, and VTP propagates it to the other switches in the VTP domain for VLAN-IDs that are lower than 1005. See the "Creating or Modifying an Ethernet VLAN" section on page 15-8 for more information about creating an RSPAN VLAN.

Use VTP pruning to get efficient flow of RSPAN traffic, or manually delete the RSPAN VLAN from all trunks that do not need to carry the RSPAN traffic.

After creating the RSPAN VLAN, begin in privileged EXEC mode, and follow these steps to start an RSPAN source session and to specify the source (monitored) ports and the destination RSPAN VLAN.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no monitor session** {*session_number* | **all** | **local** | **remote**}	Clear any existing RSPAN configuration for the session. For *session_number*, specify the session number identified with this RSPAN session. Specify **all** to remove all RSPAN sessions, **local** to remove all local sessions, or **remote** to remove all remote SPAN sessions.
Step 3	**monitor session** *session_number* **source interface** *interface-id* [**,** | **-**] [**both** | **rx** | **tx**]	Specify the RSPAN session and the source port (monitored port). For *session_number*, specify the session number identified with this RSPAN session. For *interface-id*, specify the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*). (Optional) [**,** | **-**] Specify a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen. (Optional) Specify the direction of traffic to monitor. If you do not specify a traffic direction, the source interface sends both sent and received traffic. • **both**—Monitor both received and sent traffic. • **rx**—Monitor received traffic. • **tx**—Monitor sent traffic.

	Command	Purpose
Step 4	**monitor session** *session_number* **destination remote vlan** *vlan-id* **reflector-port** *interface*	Specify the RSPAN session, the destination remote VLAN, and the reflector port. For *session_number*, enter the session number identified with this RSPAN session. For *vlan-id*, specify the RSPAN VLAN to carry the monitored traffic to the destination port. (See the "Creating or Modifying an Ethernet VLAN" section on page 15-8 for more information about creating an RSPAN VLAN.) For *interface*, specify the interface that will flood the RSPAN traffic onto the RSPAN VLAN.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show monitor** [**session** *session_number*]	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to clear any existing RSPAN configuration for session 1, configure RSPAN session 1 to monitor multiple source interfaces, and configure the destination RSPAN VLAN and the reflector-port.

```
Switch(config)# no monitor session 1
Switch(config)# monitor session 1 source interface fastEthernet0/10 tx
Switch(config)# monitor session 1 source interface fastEthernet0/2 rx
Switch(config)# monitor session 1 source interface fastEthernet0/3 rx
Switch(config)# monitor session 1 source interface port-channel 102 rx
Switch(config)# monitor session 1 destination remote vlan 901 reflector-port
fastEthernet0/1
Switch(config)# end
```

Creating an RSPAN Destination Session

Beginning in privileged EXEC mode, follow these steps to create an RSPAN destination session and to specify the source RSPAN VLAN and the destination port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**monitor session** *session_number* **source remote vlan** *vlan-id*	Specify the RSPAN session and the source RSPAN VLAN. For *session_number*, specify the session number identified with this RSPAN session. For *vlan-id*, specify the source RSPAN VLAN to monitor.
Step 3	**monitor session** *session_number* **destination interface** *interface-id* [**encapsulation** {**dot1q**}]	Specify the RSPAN session and the destination interface. For *session_number*, specify the session number identified with this RSPAN session. For *interface-id*, specify the destination interface. (Optional) Specify the encapsulation header for outgoing packets. If not specified, packets are sent in native form. • **dot1q**—Use 802.1Q encapsulation.

	Command	Purpose
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show monitor** [**session** *session_number*]	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to configure VLAN 901 as the source remote VLAN and port 5 as the destination interface:

```
Switch(config)# monitor session 1 source remote vlan 901
Switch(config)# monitor session 1 destination interface fastEthernet0/5
Switch(config)# end
```

Removing Ports from an RSPAN Session

Beginning in privileged EXEC mode, follow these steps to remove a port as an RSPAN source for a session:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no monitor session** *session_number* **source interface** *interface-id* [**,** | **-**] [**both** | **rx** | **tx**]	Specify the characteristics of the RSPAN source port (monitored port) to remove. For *session_number*, specify the session number identified with this RSPAN session. For *interface-id*, specify the source port to no longer monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*). (Optional) Use [**,** | **-**] to specify a series or range of interfaces if they were configured. Enter a space before and after the comma; enter a space before and after the hyphen. (Optional) Specify the direction of traffic (**both**, **rx**, or **tx**) to no longer monitor. If you do not specify a traffic direction, both transmit and receive are disabled.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show monitor** [**session** *session_number*]	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to remove port 1 as an RSPAN source for RSPAN session 1:

```
Switch(config)# no monitor session 1 source interface fastEthernet0/1
Switch(config)# end
```

This example shows how to disable received traffic monitoring on port 1, which was configured for bidirectional monitoring:

```
Switch(config)# no monitor session 1 source interface fastEthernet0/1 rx
```

The monitoring of traffic received on port 1 is disabled, but traffic sent from this port continues to be monitored.

Displaying SPAN and RSPAN Status

To display the status of the current SPAN or RSPAN configuration, use the **show monitor** privileged EXEC command.

This is an example of output for the **show monitor** privileged EXEC command for SPAN source session 1:

```
Switch# show monitor session 1
Session 1
---------
Type              : Local Session
Source Ports      :
    RX Only       : None
    TX Only       : None
    Both          : Fa0/4
Source VLANs      :
    RX Only       : None
    TX Only       : None
    Both          : None
Source RSPAN VLAN : None
Destination Ports : Fa0/5
    Encapsulation: DOT1Q
          Ingress: Enabled, default VLAN = 5
Reflector Port    : None
Filter VLANs      : None
Dest RSPAN VLAN   : None
```

CHAPTER 23

Configuring RMON

This chapter describes how to configure Remote Network Monitoring (RMON) on your Catalyst 2950 or Catalyst 2955 switch. RMON is a standard monitoring specification that defines a set of statistics and functions that can be exchanged between RMON-compliant console systems and network probes. RMON provides you with comprehensive network-fault diagnosis, planning, and performance-tuning information.

Note For complete syntax and usage information for the commands used in this chapter, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

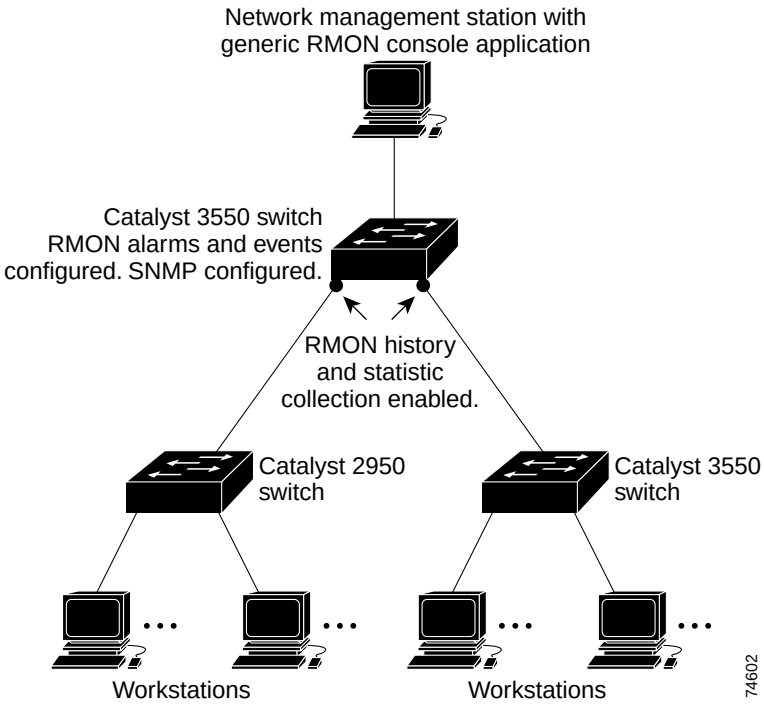
This chapter consists of these sections:

- Understanding RMON, page 23-1
- Configuring RMON, page 23-2
- Displaying RMON Status, page 23-6

Understanding RMON

RMON is an Internet Engineering Task Force (IETF) standard monitoring specification that allows various network agents and console systems to exchange network monitoring data. You can use the RMON feature with the Simple Network Management Protocol (SNMP) agent in the switch to monitor all the traffic flowing among switches on all connected LAN segments.

Figure 23-1 Remote Monitoring Example



The switch supports these RMON groups (defined in RFC 1757):

- Statistics (RMON group 1)—Collects Ethernet, Fast Ethernet, and Gigabit Ethernet statistics on an interface.
- History (RMON group 2)—Collects a history group of statistics on Ethernet, Fast Ethernet, and Gigabit Ethernet interfaces for a specified polling interval.
- Alarm (RMON group 3)—Monitors a specific management information base (MIB) object for a specified interval, triggers an alarm at a specified value (rising threshold), and resets the alarm at another value (falling threshold). Alarms can be used with events; the alarm triggers an event, which can generate a log entry or an SNMP trap.
- Event (RMON group 9)—Determines the action to take when an event is triggered by an alarm. The action can be to generate a log entry or an SNMP trap.

Because switches supported by this IOS release use hardware counters for RMON data processing, the monitoring is more efficient, and little processing power is required.

Configuring RMON

This section describes how to configure RMON on your switch. It contains this configuration information:

- Default RMON Configuration, page 23-3
- Configuring RMON Alarms and Events, page 23-3
- Configuring RMON Collection on an Interface, page 23-5

Default RMON Configuration

RMON is disabled by default; no alarms or events are configured.

Only RMON 1 is supported on the switch.

Configuring RMON Alarms and Events

You can configure your switch for RMON by using the command-line interface (CLI) or an SNMP-compatible network management station. We recommend that you use a generic RMON console application on the network management station (NMS) to take advantage of RMON's network management capabilities. You must also configure SNMP on the switch to access RMON MIB objects. For more information, see Chapter 25, "Configuring SNMP."

Beginning in privileged EXEC mode, follow these steps to enable RMON alarms and events:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**rmon alarm** *number variable interval* {**absolute** | **delta**} **rising-threshold** *value* [*event-number*] **falling-threshold** *value* [*event-number*] [**owner** *string*]	Set an alarm on a MIB object. • For *number*, specify the alarm number. The range is 1 to 65535. • For *variable*, specify the MIB object to monitor. • For *interval*, specify the time in seconds the alarm monitors the MIB variable. The range is 1 to 4294967295 seconds. • Specify the **absolute** keyword to test each MIB variable directly; specify the **delta** keyword to test the change between samples of a MIB variable. • For *value*, specify a number at which the alarm is triggered and one for when the alarm is reset. The range for the rising threshold and falling threshold *values* is -2147483648 to 2147483647. • (Optional) For *event-number*, specify the event number to trigger when the rising or falling threshold exceeds its limit. • (Optional) For **owner** *string*, specify the owner of the alarm.

	Command	Purpose
Step 3	**rmon event** *number* [**description** *string*] [**log**] [**owner** *string*] [**trap** *community*]	Add an event in the RMON event table that is associated with an RMON event number. • For *number*, assign an event number. The range is 1 to 65535. • (Optional) For **description** *string*, specify a description of the event. • (Optional) Use the **log** keyword to generate an RMON log entry when the event is triggered. • (Optional) For **owner** *string*, specify the owner of this event. • (Optional) For *community*, enter the SNMP community string used for this trap.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable an alarm, use the **no rmon alarm** *number* global configuration command on each alarm you configured. You cannot disable at once all the alarms that you configured. To disable an event, use the **no rmon event** *number* global configuration command. To learn more about alarms and events and how they interact with each other, refer to RFC 1757.

You can set an alarm on any MIB object. The following example configures RMON alarm number 10 by using the **rmon alarm** command. The alarm monitors the MIB variable *ifEntry.20.1* once every 20 seconds until the alarm is disabled and checks the change in the variable's rise or fall. If the *ifEntry.20.1* value shows a MIB counter increase of 15 or more, such as from 100000 to 100015, the alarm is triggered. The alarm in turn triggers event number 1, which is configured with the **rmon event** command. Possible events can include a log entry or an SNMP trap. If the *ifEntry.20.1* value changes by 0, the alarm is reset and can be triggered again.

```
Switch(config)# rmon alarm 10 ifEntry.20.1 20 delta rising-threshold 15 1
falling-threshold 0 owner jjohnson
```

The following example creates RMON event number 1 by using the **rmon event** command. The event is defined as *High ifOutErrors* and generates a log entry when the event is triggered by the alarm. The user *jjones* owns the row that is created in the event table by this command. This example also generates an SNMP trap when the event is triggered.

```
Switch(config)# rmon event 1 log trap eventtrap description "High ifOutErrors" owner
jjones
```

Configuring RMON Collection on an Interface

You must first configure RMON alarms and events to display collection information.

Beginning in privileged EXEC mode, follow these steps to collect group history statistics on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface on which to collect history.
Step 3	**rmon collection history** *index* [**buckets** *bucket-number*] [**interval** *seconds*] [**owner** *ownername*]	Enable history collection for the specified number of buckets and time period. • For *index*, identify the RMON group of statistics The range is 1 to 65535. • (Optional) For **buckets** *bucket-number*, specify the maximum number of buckets desired for the RMON collection history group of statistics. The range is 1 to 65535. The default is 50 buckets. • (Optional) For **interval** *seconds*, specify the number of seconds in each polling cycle. • (Optional) For **owner** *ownername*, enter the name of the owner of the RMON group of statistics.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**show rmon history**	Display the contents of the switch history table.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable history collection, use the **no rmon collection history** *index* interface configuration command.

Beginning in privileged EXEC mode, follow these steps to collect group Ethernet statistics on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface on which to collect statistics.
Step 3	**rmon collection stats** *index* [**owner** *ownername*]	Enable RMON statistic collection on the interface. • For *index*, specify the RMON group of statistics. The range is from 1 to 65535. • (Optional) For **owner** *ownername*, enter the name of the owner of the RMON group of statistics.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.

	Command	Purpose
Step 6	**show rmon statistics**	Display the contents of the switch statistics table.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable the collection of group Ethernet statistics, use the **no rmon collection stats** *index* interface configuration command.

Displaying RMON Status

To display the RMON status, use one or more of the privileged EXEC commands in Table 23-1:

Table 23-1 Commands for Displaying RMON Status

Command	Purpose
show rmon	Displays general RMON statistics.
show rmon alarms	Displays the RMON alarm table.
show rmon events	Displays the RMON event table.
show rmon history	Displays the RMON history table.
show rmon statistics	Displays the RMON statistics table.

For information about the fields in these displays, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

Configuring System Message Logging

This chapter describes how to configure system message logging on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

This chapter consists of these sections:

- Understanding System Message Logging, page 24-1
- Configuring System Message Logging, page 24-2
- Displaying the Logging Configuration, page 24-12

Understanding System Message Logging

By default, a switch sends the output from system messages and **debug** privileged EXEC commands to a logging process. The logging process controls the distribution of logging messages to various destinations, such as the logging buffer, terminal lines, or a UNIX syslog server, depending on your configuration. The process also sends messages to the console.

Note The syslog format is compatible with 4.3 BSD UNIX.

When the logging process is disabled, messages are sent only to the console. The messages are sent as they are generated, so message and debug output are interspersed with prompts or output from other commands. Messages are displayed on the console after the process that generated them has finished.

You can set the severity level of the messages to control the type of messages displayed on the console and each of the destinations. You can timestamp log messages or set the syslog source address to enhance real-time debugging and management. For information on possible messages, refer to the system message guide for this release.

You can access logged system messages by using the switch command-line interface (CLI) or by saving them to a properly configured syslog server. The switch software saves syslog messages in an internal buffer. You can remotely monitor system messages by accessing the switch through Telnet, through the console port, or by viewing the logs on a syslog server.

Configuring System Message Logging

These sections describe how to configure system message logging:

- System Log Message Format, page 24-2
- Default System Message Logging Configuration, page 24-3
- Disabling and Enabling Message Logging, page 24-4
- Setting the Message Display Destination Device, page 24-4
- Synchronizing Log Messages, page 24-6
- Enabling and Disabling Timestamps on Log Messages, page 24-7
- Enabling and Disabling Sequence Numbers in Log Messages, page 24-8
- Defining the Message Severity Level, page 24-8
- Limiting Syslog Messages Sent to the History Table and to SNMP, page 24-10
- Configuring UNIX Syslog Servers, page 24-10

System Log Message Format

System log messages can contain up to 80 characters and a percent sign (%), which follows the optional sequence number or timestamp information, if configured. Messages are displayed in this format:

seq no:timestamp: %facility-severity-MNEMONIC:description

The part of the message preceding the percent sign depends on the setting of the **service sequence-numbers**, **service timestamps log datetime**, **service timestamps log datetime** [**localtime**] [**msec**] [**show-timezone**], or **service timestamps log uptime** global configuration command.

Table 24-1 describes the elements of syslog messages.

Table 24-1 System Log Message Elements

Element	Description
seq no:	Stamps log messages with a sequence number only if the **service sequence-numbers** global configuration command is configured. For more information, see the "Enabling and Disabling Sequence Numbers in Log Messages" section on page 24-8.
timestamp formats: *mm/dd hh:mm:ss* or *hh:mm:ss* (short uptime) or *d h* (long uptime)	Date and time of the message or event. This information appears only if the **service timestamps log** [**datetime** | **log**] global configuration command is configured. For more information, see the "Enabling and Disabling Timestamps on Log Messages" section on page 24-7.
facility	The facility to which the message refers (for example, SNMP, SYS, and so forth). For a list of supported facilities, see Table 24-4 on page 24-12.
severity	Single-digit code from 0 to 7 that is the severity of the message. For a description of the severity levels, see Table 24-3 on page 24-9.

Table 24-1 System Log Message Elements (continued)

Element	Description
MNEMONIC	Text string that uniquely describes the message.
description	Text string containing detailed information about the event being reported.

This example shows a partial switch system message:

```
00:00:46: %LINK-3-UPDOWN: Interface Port-channel1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to up
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed
state to down 2
*Mar  1 18:46:11: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
18:47:02: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
*Mar  1 18:48:50.483 UTC: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
```

Default System Message Logging Configuration

Table 24-2 shows the default system message logging configuration.

Table 24-2 Default System Message Logging Configuration

Feature	Default Setting
System message logging to the console	Enabled.
Console severity	Debugging (and numerically lower levels; see Table 24-3 on page 24-9).
Logging buffer size	4096 bytes.
Logging history size	1 message.
Timestamps	Disabled.
Synchronous logging	Disabled.
Logging server	Disabled.
Syslog server IP address	None configured.
Server facility	Local7 (see Table 24-4 on page 24-12).
Server severity	Informational (and numerically lower levels; see Table 24-3 on page 24-9).

Disabling and Enabling Message Logging

Message logging is enabled by default. It must be enabled to send messages to any destination other than the console. When enabled, log messages are sent to a logging process, which logs messages to designated locations asynchronously to the processes that generated the messages.

Beginning in privileged EXEC mode, follow these steps to disable message logging:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no logging on**	Disable message logging.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config** or **show logging**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Disabling the logging process can slow down the switch because a process must wait until the messages are written to the console before continuing. When the logging process is disabled, messages are displayed on the console as soon as they are produced, often appearing in the middle of command output.

The **logging synchronous** global configuration command also affects the display of messages to the console. When this command is enabled, messages appear only after you press Return. For more information, see the "Synchronizing Log Messages" section on page 24-6.

To re-enable message logging after it has been disabled, use the **logging on** global configuration command.

Setting the Message Display Destination Device

If message logging is enabled, you can send messages to specific locations in addition to the console. Beginning in privileged EXEC mode, use one or more of the following commands to specify the locations that receive messages:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**logging buffered** [*size*]	Log messages to an internal buffer. The default buffer size is 4096. The range is 4096 to 4294967295 bytes. **Note** Do not make the buffer size too large because the switch could run out of memory for other tasks. Use the **show memory** privileged EXEC command to view the free processor memory on the switch; however, this value is the maximum available, and the buffer size should *not* be set to this amount.

	Command	Purpose
Step 3	**logging** *host*	Log messages to a UNIX syslog server host. For *host*, specify the name or IP address of the host to be used as the syslog server. To build a list of syslog servers that receive logging messages, enter this command more than once. For complete syslog server configuration steps, see the "Configuring UNIX Syslog Servers" section on page 24-10.
Step 4	**logging file flash:***filename* [*max-file-size*] [*min-file-size*] [*severity-level-number* | *type*]	Store log messages in a file in Flash memory. • For *filename*, enter the log message filename. • (Optional) For *max-file-size*, specify the maximum logging file size. The range is 4096 to 2147483647. The default is 4069 bytes. • (Optional) For *min-file-size*, specify the minimum logging file size. The range is 1024 to 2147483647. The default is 2048 bytes. • (Optional) For *severity-level-number* | *type*, specify either the logging severity level or the logging type. The severity range is 0 to 7. For a list of logging type keywords, see Table 24-3 on page 24-9. By default, the log file receives debugging messages and numerically lower levels.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**terminal monitor**	Log messages to a nonconsole terminal during the current session. Terminal parameter-setting commands are set locally and do not remain in effect after the session has ended. You must perform this step for each session to see the debugging messages.
Step 7	**show running-config**	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The **logging buffered** global configuration command copies logging messages to an internal buffer. The buffer is circular, so newer messages overwrite older messages after the buffer is full. To display the messages that are logged in the buffer, use the **show logging** privileged EXEC command. The first message displayed is the oldest message in the buffer. To clear the contents of the buffer, use the **clear logging** privileged EXEC command.

To disable logging to the console, use the **no logging console** global configuration command. To disable logging to a file, use the **no logging file** [*severity-level-number* | *type*] global configuration command.

Synchronizing Log Messages

You can configure the system to synchronize unsolicited messages and **debug** privileged EXEC command output with solicited device output and prompts for a specific console port line or virtual terminal line. You can identify the types of messages to be output asynchronously based on the level of severity. You can also determine the maximum number of buffers for storing asynchronous messages for the terminal after which messages are dropped.

When synchronous logging of unsolicited messages and **debug** command output is enabled, unsolicited device output is displayed on the console or printed after solicited device output is displayed or printed. Unsolicited messages and **debug** command output is displayed on the console after the prompt for user input is returned. Therefore, unsolicited messages and **debug** command output are not interspersed with solicited device output and prompts. After the unsolicited messages are displayed, the console again displays the user prompt.

Beginning in privileged EXEC mode, follow these steps to configure synchronous logging:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**line** [**console** | **vty**] *line-number* [*ending-line-number*]	Specify the line to be configured for synchronous logging of messages. • Use the **console** keyword for configurations that occur through the switch console port. • Use the **line vty** *line-number* command to specify which vty lines are to have synchronous logging enabled. You use a vty connection for configurations that occur through a Telnet session. The range of line numbers is from 0 to 15. You can change the setting of all 16 vty lines at once by entering: **line vty 0 15** Or you can change the setting of the single vty line being used for your current connection. For example, to change the setting for vty line 2, enter: **line vty 2** When you enter this command, the mode changes to line configuration.
Step 3	**logging synchronous** [**level** *severity-level* | **all**] [**limit** *number-of-buffers*]	Enable synchronous logging of messages. • (Optional) For **level** *severity-level*, specify the message severity level. Messages with a severity level equal to or higher than this value are printed asynchronously. Low numbers mean greater severity and high numbers mean lesser severity. The default is 2. • (Optional) Specifying **level all** means that all messages are printed asynchronously regardless of the severity level. • (Optional) For **limit** *number-of-buffers*, specify the number of buffers to be queued for the terminal after which new messages are dropped. The default is 20.
Step 4	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable synchronization of unsolicited messages and debug output, use the **no logging synchronous** [**level** *severity-level* | **all**] [**limit** *number-of-buffers*] line configuration command.

Enabling and Disabling Timestamps on Log Messages

By default, log messages are not timestamped.

Beginning in privileged EXEC mode, follow these steps to enable timestamping of log messages:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**service timestamps log uptime** or **service timestamps log datetime** [**msec**] [**localtime**] [**show-timezone**]	Enable log timestamps. The first command enables timestamps on log messages, showing the time since the system was rebooted. The second command enables timestamps on log messages. Depending on the options selected, the timestamp can include the date, time in milliseconds relative to the local time zone, and the time zone name.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable timestamps for both debug and log messages, use the **no service timestamps** global configuration command.

This example shows part of a logging display with the **service timestamps log datetime** global configuration command enabled:

```
*Mar  1 18:46:11: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
```

This example shows part of a logging display with the s**ervice timestamps log uptime** global configuration command enabled:

```
00:00:46: %LINK-3-UPDOWN: Interface Port-channel1, changed state to up
```

Enabling and Disabling Sequence Numbers in Log Messages

Because there is a chance that more than one log message can have the same timestamp, you can display messages with sequence numbers so that you can unambiguously refer to a single message. By default, sequence numbers in log messages are not displayed.

Beginning in privileged EXEC mode, follow these steps to enable sequence numbers in log messages:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**service sequence-numbers**	Enable sequence numbers.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable sequence numbers, use the **no service sequence-numbers** global configuration command.

This example shows part of a logging display with sequence numbers enabled:

```
000019: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
```

Defining the Message Severity Level

You can limit messages displayed to the selected device by specifying the severity level of the message, which are described in Table 24-3.

Beginning in privileged EXEC mode, follow these steps to define the message severity level:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**logging console** *level*	Limit messages logged to the console. By default, the console receives debugging messages and numerically lower levels (see Table 24-3 on page 24-9).
Step 3	**logging monitor** *level*	Limit messages logged to the terminal lines. By default, the terminal receives debugging messages and numerically lower levels (see Table 24-3 on page 24-9).
Step 4	**logging trap** *level*	Limit messages logged to the syslog servers. By default, syslog servers receive informational messages and numerically lower levels (see Table 24-3 on page 24-9). For complete syslog server configuration steps, see the "Configuring UNIX Syslog Servers" section on page 24-10.
Step 5	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 6	**show running-config** or **show logging**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note Specifying a *level* causes messages at that level and numerically lower levels to be displayed at the destination.

To disable logging to the console, use the **no logging console** global configuration command. To disable logging to a terminal other than the console, use the **no logging monitor** global configuration command. To disable logging to syslog servers, use the **no logging trap** global configuration command.

Table 24-3 describes the *level* keywords. It also lists the corresponding UNIX syslog definitions from the most severe level to the least severe level.

Table 24-3 Message Logging Level Keywords

Level Keyword	Level	Description	Syslog Definition
emergencies	0	System unstable	LOG_EMERG
alerts	1	Immediate action needed	LOG_ALERT
critical	2	Critical conditions	LOG_CRIT
errors	3	Error conditions	LOG_ERR
warnings	4	Warning conditions	LOG_WARNING
notifications	5	Normal but significant condition	LOG_NOTICE
informational	6	Informational messages only	LOG_INFO
debugging	7	Debugging messages	LOG_DEBUG

The software generates four other categories of messages:

- Error messages about software or hardware malfunctions, displayed at levels **warnings** through **emergencies**. These types of messages mean that the functionality of the switch is affected. For information on how to recover from these malfunctions, refer to the system message guide for this release.
- Output from the **debug** commands, displayed at the **debugging** level. Debug commands are typically used only by the Technical Assistance Center.
- Interface up or down transitions and system restart messages, displayed at the **notifications** level. This message is only for information; switch functionality is not affected.
- Reload requests and low-process stack messages, displayed at the **informational** level. This message is only for information; switch functionality is not affected.

Limiting Syslog Messages Sent to the History Table and to SNMP

If you enabled syslog message traps to be sent to an SNMP network management station by using the **snmp-server enable trap** global configuration command, you can change the level of messages sent and stored in the switch history table. You also can change the number of messages that are stored in the history table.

Messages are stored in the history table because SNMP traps are not guaranteed to reach their destination. By default, one message of the level **warning** and numerically lower levels (see Table 24-3 on page 24-9) are stored in the history table even if syslog traps are not enabled.

Beginning in privileged EXEC mode, follow these steps to change the level and history table size defaults:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**logging history** *level*[1]	Change the default level of syslog messages stored in the history file and sent to the SNMP server. See Table 24-3 on page 24-9 for a list of *level* keywords. By default, **warnings**, **errors**, **critical**, **alerts**, and **emergencies** messages are sent.
Step 3	**logging history size** *number*	Specify the number of syslog messages that can be stored in the history table. The default is to store one message. The range is 1 to 500 messages.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

1. Table 24-3 lists the level keywords and severity level. For SNMP usage, the severity level values increase by 1. For example, emergencies equal 1, not 0, and critical equals 3, not 2.

When the history table is full (it contains the maximum number of message entries specified with the **logging history size** global configuration command), the oldest message entry is deleted from the table to allow the new message entry to be stored.

To return the logging of syslog messages to the default level, use the **no logging history** global configuration command. To return the number of messages in the history table to the default value, use the **no logging history size** global configuration command.

Configuring UNIX Syslog Servers

The next sections describe how to configure the UNIX server syslog daemon and how to define the UNIX system logging facility.

Logging Messages to a UNIX Syslog Daemon

Before you can send system log messages to a UNIX syslog server, you must configure the syslog daemon on a UNIX server. Log in as root, and perform these steps:

Note Some recent versions of UNIX syslog daemons no longer accept by default syslog packets from the network. If this is the case with your system, use the UNIX **man syslogd** command to determine what options must be added to or removed from the syslog command line to enable logging of remote syslog messages.

Step 1 Add a line such as the following to the file /etc/syslog.conf:

```
local7.debug /usr/adm/logs/cisco.log
```

The **local7** keyword specifies the logging facility to be used; see Table 24-4 on page 24-12 for information on the facilities. The **debug** keyword specifies the syslog level; see Table 24-3 on page 24-9 for information on the severity levels. The syslog daemon sends messages at this level or at a more severe level to the file specified in the next field. The file must already exist, and the syslog daemon must have permission to write to it.

Step 2 Create the log file by entering these commands at the UNIX shell prompt:

```
$ touch /var/log/cisco.log
$ chmod 666 /var/log/cisco.log
```

Step 3 Make sure the syslog daemon reads the new changes:

```
$ kill -HUP `cat /etc/syslog.pid`
```

For more information, see the **man syslog.conf** and **man syslogd** commands on your UNIX system.

Configuring the UNIX System Logging Facility

When sending system log messages to an external device, you can cause the switch to identify its messages as originating from any of the UNIX syslog facilities.

Beginning in privileged EXEC mode, follow these steps to configure UNIX system facility message logging:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**logging** *host*	Log messages to a UNIX syslog server host by entering its IP address. To build a list of syslog servers that receive logging messages, enter this command more than once.
Step 3	**logging trap** *level*	Limit messages logged to the syslog servers. Be default, syslog servers receive informational messages and lower. See Table 24-3 on page 24-9 for *level* keywords.

	Command	Purpose
Step 4	**logging facility** *facility-type*	Configure the syslog facility. See Table 24-4 on page 24-12 for *facility-type* keywords. The default is **local7**.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a syslog server, use the **no logging** *host* global configuration command, and specify the syslog server IP address. To disable logging to syslog servers, enter the **no logging trap** global configuration command.

Table 24-4 lists the UNIX system facilities supported by the Cisco IOS software. For more information about these facilities, consult the operator's manual for your UNIX operating system.

Table 24-4 Logging Facility-Type Keywords

Facility Type Keyword	Description
auth	Authorization system
cron	Cron facility
daemon	System daemon
kern	Kernel
local0-7	Locally defined messages
lpr	Line printer system
mail	Mail system
news	USENET news
sys9	System use
sys10	System use
sys11	System use
sys12	System use
sys13	System use
sys14	System use
syslog	System log
user	User process
uucp	UNIX-to-UNIX copy system

Displaying the Logging Configuration

To display the logging configuration and the contents of the log buffer, use the **show logging** privileged EXEC command. For information about the fields in this display, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

Configuring SNMP

This chapter describes how to configure the Simple Network Management Protocol (SNMP) on your Catalyst 2950 or Catalyst 2955 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the switch command reference for this release and to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

This chapter consists of these sections:

- Understanding SNMP, page 25-1
- Configuring SNMP, page 25-5
- Displaying SNMP Status, page 25-16

Understanding SNMP

SNMP is an application-layer protocol that provides a message format for communication between managers and agents. The SNMP system consists of an SNMP manager, an SNMP agent, and a management information base (MIB). The SNMP manager can be part of a network management system (NMS) such as CiscoWorks. The agent and MIB reside on the switch. To configure SNMP on the switch, you define the relationship between the manager and the agent.

The SNMP agent contains MIB variables whose values the SNMP manager can request or change. A manager can get a value from an agent or store a value into the agent. The agent gathers data from the MIB, the repository for information about device parameters and network data. The agent can also respond to a manager's requests to get or set data.

An agent can send unsolicited traps to the manager. Traps are messages alerting the SNMP manager to a condition on the network. Traps can mean improper user authentication, restarts, link status (up or down), MAC address tracking, closing of a TCP connection, loss of connection to a neighbor, or other significant events.

This section includes information about these topics:

- SNMP Versions, page 25-2
- SNMP Manager Functions, page 25-3
- SNMP Agent Functions, page 25-4
- SNMP Community Strings, page 25-4

- Using SNMP to Access MIB Variables, page 25-4
- SNMP Notifications, page 25-5

SNMP Versions

This software release supports these SNMP versions:

- SNMPv1—The Simple Network Management Protocol, a Full Internet Standard, defined in RFC 1157.
- SNMPv2C replaces the Party-based Administrative and Security Framework of SNMPv2Classic with the community-string-based Administrative Framework of SNMPv2C while retaining the bulk retrieval and improved error handling of SNMPv2Classic. It has these features:
  - SNMPv2—Version 2 of the Simple Network Management Protocol, a Draft Internet Standard, defined in RFCs 1902 through 1907.
  - SNMPv2C—The community-string-based Administrative Framework for SNMPv2, an Experimental Internet Protocol defined in RFC 1901.
- SNMPv3—Version 3 of the SNMP is an interoperable standards-based protocol defined in RFCs 2273 to 2275. SNMPv3 provides secure access to devices by authenticating and encrypting packets over the network and includes these security features:
  - Message integrity—ensuring that a packet was not tampered with in transit
  - Authentication—determining that the message is from a valid source
  - Encryption—mixing the contents of a package to prevent it from being read by an unauthorized source.

Note To select encryption, enter the **priv** keyword. This keyword is available only when the cryptographic (encrypted) software image is installed.

Both SNMPv1 and SNMPv2C use a community-based form of security. The community of managers able to access the agent's MIB is defined by an IP address access control list and password.

SNMPv2C includes a bulk retrieval mechanism and more detailed error message reporting to management stations. The bulk retrieval mechanism retrieves tables and large quantities of information, minimizing the number of round-trips required. The SNMPv2C improved error-handling includes expanded error codes that distinguish different kinds of error conditions; these conditions are reported through a single error code in SNMPv1. Error return codes in SNMPv2C report the error type.

SNMPv3 provides for both security models and security levels. A security model is an authentication strategy set up for a user and the group within which the user resides. A security level is the permitted level of security within a security model. A combination of the security level and the security model determine which security mechanism is used when handling an SNMP packet. Available security models are SNMPv1, SNMPv2C, and SNMPv3.

Table 25-1 identifies the characteristics of the different combinations of security models and levels.

Table 25-1 SNMP Security Models and Levels

Model	Level	Authentication	Encryption	Result
SNMPv1	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
SNMPv2C	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
SNMPv3	noAuthNoPriv	Username	No	Uses a username match for authentication.
SNMPv3	authNoPriv	MD5 or SHA	No	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms.
SNMPv3	authPriv (requires the cryptographic software image)	MD5 or SHA	DES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides DES 56-bit encryption in addition to authentication based on the CBC-DES (DES-56) standard.

You must configure the SNMP agent to use the SNMP version supported by the management station. Because an agent can communicate with multiple managers, you can configure the software to support communications with one management station using the SNMPv1 protocol, one using the SNMPv2C protocol and another using SNMPv3.

SNMP Manager Functions

The SNMP manager uses information in the MIB to perform the operations described in Table 25-2.

Table 25-2 SNMP Operations

Operation	Description
get-request	Retrieves a value from a specific variable.
get-next-request	Retrieves a value from a variable within a table.[1]
get-bulk-request[2]	Retrieves large blocks of data, such as multiple rows in a table, that would otherwise require the transmission of many small blocks of data.
get-response	Replies to a get-request, get-next-request, and set-request sent by an NMS.
set-request	Stores a value in a specific variable.
trap	An unsolicited message sent by an SNMP agent to an SNMP manager when some event has occurred.

1. With this operation, an SNMP manager does not need to know the exact variable name. A sequential search is performed to find the needed variable from within a table.
2. The **get-bulk** command only works with SNMPv2 or later.

SNMP Agent Functions

The SNMP agent responds to SNMP manager requests as follows:

- Get a MIB variable—The SNMP agent begins this function in response to a request from the NMS. The agent retrieves the value of the requested MIB variable and responds to the NMS with that value.
- Set a MIB variable—The SNMP agent begins this function in response to a message from the NMS. The SNMP agent changes the value of the MIB variable to the value requested by the NMS.

The SNMP agent also sends unsolicited trap messages to notify an NMS that a significant event has occurred on the agent. Examples of trap conditions include, but are not limited to, when a port or module goes up or down, when spanning-tree topology changes occur, and when authentication failures occur.

SNMP Community Strings

SNMP community strings authenticate access to MIB objects and function as embedded passwords. In order for the NMS to access the switch, the community string definitions on the NMS must match at least one of the three community string definitions on the switch.

A community string can have one of these attributes:

- Read-only (RO)—Gives read access to authorized management stations to all objects in the MIB except the community strings, but does not allow write access
- Read-write (RW)—Gives read and write access to authorized management stations to all objects in the MIB, but does not allow access to the community strings
- Read-write-all—Gives read and write access to authorized management stations to all objects in the MIB, including the community strings

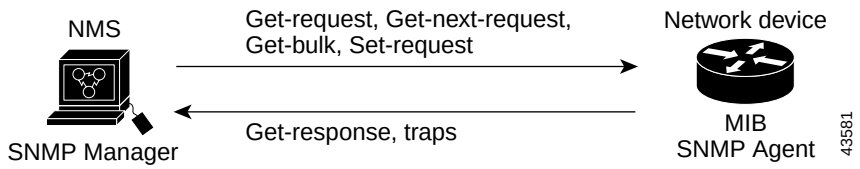
Note When a cluster is created, the command switch manages the exchange of messages among member switches and the SNMP application. The Cluster Management software appends the member switch number (*@esN*, where *N* is the switch number) to the first configured RW and RO community strings on the command switch and propagates them to the member switches. For more information, see Chapter 7, "Clustering Switches."

Using SNMP to Access MIB Variables

An example of an NMS is the CiscoWorks network management software. CiscoWorks 2000 software uses the switch MIB variables to set device variables and to poll devices on the network for specific information. The results of a poll can be displayed as a graph and analyzed to troubleshoot internetworking problems, increase network performance, verify the configuration of devices, monitor traffic loads, and more.

As shown in Figure 25-1, the SNMP agent gathers data from the MIB. The agent can send traps, or notification of certain events, to the SNMP manager, which receives and processes the traps. Traps alert the SNMP manager to a condition on the network such as improper user authentication, restarts, link status (up or down), MAC address tracking, and so forth. The SNMP agent also responds to MIB-related queries sent by the SNMP manager in *get-request*, *get-next-request*, and *set-request* format.

Figure 25-1 SNMP Network



For information on supported MIBs and how to access them, see Appendix A, "Supported MIBs."

SNMP Notifications

SNMP allows the switch to send notifications to SNMP managers when particular events occur. SNMP notifications can be sent as traps or inform requests. In command syntax, unless there is an option in the command to select either traps or informs, the keyword *traps* refers to either traps or informs, or both. Use the **snmp-server host** command to specify whether to send SNMP notifications as traps or informs.

Traps are unreliable because the receiver does not send an acknowledgment when it receives a trap, and the sender cannot determine if the trap was received. When an SNMP manager receives an inform request, it acknowledges the message with an SNMP response protocol data unit (PDU). If the sender does not receive a response, the inform request can be sent again. Because they can be re-sent, informs are more likely than traps to reach their intended destination.

The characteristics that make informs more reliable than traps also consume more resources in the switch and in the network. Unlike a trap, which is discarded as soon as it is sent, an inform request is held in memory until a response is received or the request times out. Traps are sent only once, but an inform might be re-sent or retried several times. The retries increase traffic and contribute to a higher overhead on the network. Therefore, traps and informs require a trade-off between reliability and resources. If it is important that the SNMP manager receive every notification, use inform requests. If traffic on the network or memory in the switch is a concern and notification is not required, use traps.

Note SNMPv1 does not support informs.

Configuring SNMP

This section describes how to configure SNMP on your switch. It contains this configuration information:

- Default SNMP Configuration, page 25-6
- SNMP Configuration Guidelines, page 25-6
- Disabling the SNMP Agent, page 25-7
- Configuring Community Strings, page 25-7
- Configuring SNMP Groups and Users, page 25-9
- Configuring SNMP Notifications, page 25-11
- Setting the Agent Contact and Location Information, page 25-14
- Limiting TFTP Servers Used Through SNMP, page 25-14
- SNMP Examples, page 25-15

Default SNMP Configuration

Table 25-3 shows the default SNMP configuration.

Table 25-3 Default SNMP Configuration

Feature	Default Setting
SNMP agent	Enabled
SNMP community strings	Read-Only: Public Read-Write: Private Read-Write-all: Secret
SNMP trap receiver	None configured
SNMP traps	None enabled
SNMP version	If no **version** keyword is present, the default is version 1.
SNMPv3 authentication	If no keyword is entered, the default is the **noauth** (noAuthNoPriv) security level.
SNMP notification type	If no type is specified, all notifications are sent.

SNMP Configuration Guidelines

An SNMP *group* is a table that maps SNMP users to SNMP views. An SNMP *user* is a member of an SNMP group. An SNMP *host* is the recipient of an SNMP trap operation. An SNMP *engine ID* is a name for the local or remote SNMP engine.

Note Before using alarm profiles to set the Catalyst 2955 switch to send SNMP alarm trap notifications to an SNMP server, you must first enable SNMP by using the **snmp-server enable traps alarms** global configuration command.

When configuring SNMP, follow these guidelines:

- When configuring an SNMP group, do not specify a notify view. The **snmp-server host** global configuration command autogenerates a notify view for the user and then adds it to the group associated with that user. Modifying the group's notify view affects all users associated with that group. Refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1* for information about when you should configure notify views.
- To configure a remote user, specify the IP address or port number for the remote SNMP agent of the device where the user resides.
- Before you configure remote users for a particular agent, configure the SNMP engine ID, using the **snmp-server engineID** global configuration with the **remote** option. The remote agent's SNMP engine ID and user password are used to compute the authentication and privacy digests. If you do not configure the remote engine ID first, the configuration command fails.
- When configuring SNMP informs, you need to configure the SNMP engine ID for the remote agent in the SNMP database before you can send proxy requests or informs to it.
- Changing the value of the SNMP engine ID has important side effects. A user's password (entered on the command line) is converted to an MD5 or SHA security digest based on the password and the local engine ID. The command-line password is then destroyed, as required by RFC 2274. Because

of this deletion, if the value of engineID changes, the security digests of SNMPv3 users become invalid, and you need to reconfigure SNMP users by using the **snmp-server user** *username* global configuration command. Similar restrictions require the reconfiguration of community strings when the engine ID changes.

Disabling the SNMP Agent

Beginning in privileged EXEC mode, follow these steps to disable the SNMP agent:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no snmp-server**	Disable the SNMP agent operation.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The **no snmp-server** global configuration command disables all running versions (version 1, version 2C, and version 3) on the device. No specific IOS command exists to enable SNMP. The first **snmp-server** global configuration command that you enter enables all versions of SNMP.

Configuring Community Strings

You use the SNMP community string to define the relationship between the SNMP manager and the agent. The community string acts like a password to permit access to the agent on the switch. Optionally, you can specify one or more of these characteristics associated with the string:

- An access list of IP addresses of the SNMP managers that are permitted to use the community string to gain access to the agent
- A MIB view, which defines the subset of all MIB objects accessible to the given community
- Read and write or read-only permission for the MIB objects accessible to the community

Beginning in privileged EXEC mode, follow these steps to configure a community string on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server community** *string* [**view** *view-name*] [**ro** | **rw**] [*access-list-number*]	Configure the community string. • For *string*, specify a string that acts like a password and permits access to the SNMP protocol. You can configure one or more community strings of any length. • (Optional) For **view**, specify the view record accessible to the community. • (Optional) Specify either read-only (**ro**) if you want authorized management stations to retrieve MIB objects, or specify read-write (**rw**) if you want authorized management stations to retrieve and modify MIB objects. By default, the community string permits read-only access to all objects. • (Optional) For *access-list-number*, enter an IP standard access list numbered from 1 to 99 and 1300 to 1999.
Step 3	**access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*]	(Optional) If you specified an IP standard access list number in Step 2, then create the list, repeating the command as many times as necessary. • For *access-list-number*, enter the access list number specified in Step 2. • The **deny** keyword denies access if the conditions are matched. The **permit** keyword permits access if the conditions are matched. • For *source*, enter the IP address of the SNMP managers that are permitted to use the community string to gain access to the agent. • (Optional) For *source-wildcard*, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore. Recall that the access list is always terminated by an implicit deny statement for everything.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Note To disable access for an SNMP community, set the community string for that community to the null string (do not enter a value for the community string).

To remove a specific community string, use the **no snmp-server community** *string* global configuration command.

This example shows how to assign the string *comaccess* to SNMP, to allow read-only access, and to specify that IP access list 4 can use the community string to gain access to the switch SNMP agent:

```
Switch(config)# snmp-server community comaccess ro 4
```

Configuring SNMP Groups and Users

You can specify an identification name (engineID) for the local or remote SNMP server engine on the switch. You can configure an SNMP server group that maps SNMP users to SNMP views, and you can add new users to the SNMP group.

Beginning in privileged EXEC mode, follow these steps to configure SNMP on the switch:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server engineID** {**local** *engineid-string* | **remote** *ip-address* [**udp-port** *port-number*] *engineid-string*}	Configure a name for either the local or remote copy of SNMP. • The *engineid-string* is a 24-character ID string with the name of the copy of SNMP. You need not specify the entire 24-character engine ID if it contains trailing zeros. Specify only the portion of the engine ID up to the point where only zeros remain in the value. For example, to configure an engine ID of 123400000000000000000000, you can enter this: **snmp-server engineID local 1234** • If you select **remote**, specify the *ip-address* of the device that contains the remote copy of SNMP and the optional UDP port on the remote device. The default is 162.

	Command	Purpose
Step 3	**snmp-server group** *groupname* {**v1** | **v2c** | **v3** [**auth** | **noauth** | **priv**]} [**read** *readview*] [**write** *writeview*] [**notify** *notifyview*] [**access** *access-list*]	Configure a new SNMP group on the remote device. • For *groupname*, specify the name of the group. • Specify a security model: – **v1** is the least secure of the possible security models. – **v2c** is the second least secure model. It allows transmission of informs and integers twice the normal width. – **v3,** the most secure, requires you to select an authentication level: **auth**—Enables the Message Digest 5 (MD5) and the Secure Hash Algorithm (SHA) packet authentication. **noauth** —The noAuthNoPriv security level. This is the default if no keyword is specified. **priv**—Enables Data Encryption Standard (DES) packet encryption (also called *privacy*). **Note** The **priv** keyword is available only when the cryptographic software image is installed. • (Optional) Enter **read** *readview* with a string (not to exceed 64 characters) that is the name of the view in which you can only view the contents of the agent. • (Optional) Enter **write** *writeview* with a string (not to exceed 64 characters) that is the name of the view in which you enter data and configure the contents of the agent. • (Optional) Enter **notify** *notifyview* with a string (not to exceed 64 characters) that is the name of the view in which you specify a notify, inform, or trap. • (Optional) Enter **access** *access-list* with a string (not to exceed 64 characters) that is the name of the access list.

	Command	Purpose
Step 4	**snmp-server user** *username groupname* [**remote** *host* [**udp-port** *port*]] {**v1** | **v2c** | **v3** [**auth** {**md5** | **sha**} *auth-password*]} [**encrypted**] [**access** *access-list*]	Configure a new user to an SNMP group. • The *username* is the name of the user on the host that connects to the agent. • The *groupname* is the name of the group to which the user is associated. • (Optional) Enter **remote** to specify a remote SNMP entity to which the user belongs and the hostname or IP address of that entity with the optional UDP port number. The default is 162. • Enter the SNMP version number (**v1**, **v2c**, or **v3**). If you enter **v3**, you have these additional options: – **auth** is an authentication level setting session, which can be either the HMAC-MD5-96 or the HMAC-SHA-96 authentication level, and requires a password string (not to exceed 64 characters). – **encrypted** specifies that the password appears in encrypted format. • (Optional) Enter **access** *access-list* with a string (not to exceed 64 characters) that is the name of the access list.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Configuring SNMP Notifications

A trap manager is a management station that receives and processes traps. Traps are system alerts that the switch generates when certain events occur. By default, no trap manager is defined, and no traps are sent. Switches running this IOS release can have an unlimited number of trap managers.

Note Many commands use the word *traps* in the command syntax. Unless there is an option in the command to select either traps or informs, the keyword *traps* refers to either traps, informs, or both. Use the **snmp-server host** command to specify whether to send SNMP notifications as traps or informs.

Table 25-4 describes the supported switch traps (notification types). You can enable any or all of these traps and configure a trap manager to receive them.

Table 25-4 Switch Notification Types

Notification Type Keyword	Description
alarms	Generates SNMP alarm traps (Catalyst 2955 switch only).
c2900	Generates a trap for Catalyst 2950- and Catalyst 2955-specific notifications.
cluster	Generates a trap when the cluster configuration changes.
config	Generates a trap for SNMP configuration changes.

Table 25-4 Switch Notification Types (continued)

Notification Type Keyword	Description
entity	Generates a trap for SNMP entity changes.
hsrp	Generates a trap for Hot Standby Router Protocol (HSRP) changes.
mac-notification	Generates a trap for MAC address notifications.
rtr	Generates a trap for the SNMP Response Time Reporter (RTR).
snmp	Generates a trap for SNMP-type notifications.
syslog	Generates a trap for SNMP syslog notifications.
tty	Sends Cisco enterprise-specific notifications when a Transmission Control Protocol (TCP) connection closes.
udp-port	Sends notification of the User Datagram Protocol (UDP) port number of the host.
vlan-membership	Generates a trap for SNMP VLAN membership changes.
vtp	Generates a trap for VLAN Trunking Protocol (VTP) changes.

Some notification types cannot be controlled with the **snmp-server enable** global configuration command, for example, **tty** and **udp-port**. These notification types are always enabled. You can use the **snmp-server host** global configuration command to a specific host to receive the notification types listed in Table 25-4.

Beginning in privileged EXEC mode, follow these steps to configure the switch to send traps or informs to a host:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server engineID remote** *ip-address engineid-string*	Specify the engine ID for the remote host.
Step 3	**snmp-server user** *username groupname* **remote** *host* [**udp-port** *port*] {**v1** | **v2c** | **v3** [**auth** {**md5** | **sha**} *auth-password*]} [**encrypted**] [**access** *access-list*]	Configure an SNMP user to be associated with the remote host created in Step 2. **Note** You cannot configure a remote user for an address without first configuring the engine ID for the remote host. If you try to configure the user before configuring the remote engine ID, you receive an error message, and the command is not executed.
Step 4	**snmp-server group** [*groupname* {**v1** | **v2c** | **v3** [**auth** | **noauth**]}] [**read** *readview*] [**write** *writeview*] [**notify** *notifyview*] [**access** *access-list*]	Configure an SNMP group.

	Command	Purpose
Step 5	**snmp-server host** *host-addr* [**traps** | **informs**] [**version** {**1** | **2c** | **3** [**auth** | **noauth** | **priv**]}] *community-string* [**udp-port** *port*] [*notification-type*]	Specify the recipient of an SNMP trap operation. • For *host-addr*, specify the name or Internet address of the host (the targeted recipient). • (Optional) Enter **traps** (the default) to send SNMP traps to the host. • (Optional) Enter **informs** to send SNMP informs to the host. • (Optional) Specify the SNMP **version** (**1**, **2c**, or **3**). SNMPv1 is not available with informs. • (Optional) For version 3, select authentication level **auth, noauth**, or **priv.** **Note** The **priv** keyword is available only when the cryptographic software image is installed. • For *community-string*, enter the password-like community string sent with the notification operation. • (Optional) For **udp-port** *port*, enter the UDP port on the remote device. • (Optional) For *notification-type*, use the keywords listed in Table 25-4 on page 25-11. If no type is specified, all notifications are sent.
Step 6	**snmp-server enable traps** *notification-types*	Enable the switch to send traps or informs and specify the type of notifications to be sent. For a list of notification types, see Table 25-4 on page 25-11, or enter this: **snmp-server enable traps ?** To enable multiple types of traps, you must enter a separate **snmp-server enable traps** command for each trap type.
Step 7	**snmp-server trap-source** *interface-id*	(Optional) Specify the source interface, which provides the IP address for the trap message. This command also sets the source IP address for informs.
Step 8	**snmp-server queue-length** *length*	(Optional) Establish the message queue length for each trap host. The range is 1 to 1000; the default is 10.
Step 9	**snmp-server trap-timeout** *seconds*	(Optional) Define how often to resend trap messages. The range is 1 to 1000; the default is 30 seconds.
Step 10	**end**	Return to privileged EXEC mode.
Step 11	**show running-config**	Verify your entries.
Step 12	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

The **snmp-server host** command specifies which hosts receive the notifications. The **snmp-server enable trap** command globally enables the mechanism for the specified notification (for traps and informs). To enable a host to receive an inform, you must configure an **snmp-server host informs** command for the host and globally enable informs by using the **snmp-server enable traps** command.

To remove the specified host from receiving traps, use the **no snmp-server host** *host* global configuration command. The **no snmp-server host** command with no keywords disables traps, but not informs, to the host. To disable informs, use the **no snmp-server host informs** global configuration command. To disable a specific trap type, use the **no snmp-server enable traps** *notification-types* global configuration command.

Setting the Agent Contact and Location Information

Beginning in privileged EXEC mode, follow these steps to set the system contact and location of the SNMP agent so that these descriptions can be accessed through the configuration file:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server contact** *text*	Set the system contact string. For example: `snmp-server contact Dial System Operator at beeper 21555.`
Step 3	**snmp-server location** *text*	Set the system location string. For example: `snmp-server location Building 3/Room 222`
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Limiting TFTP Servers Used Through SNMP

Beginning in privileged EXEC mode, follow these steps to limit the TFTP servers used for saving and loading configuration files through SNMP to the servers specified in an access list:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**snmp-server tftp-server-list** *access-list-number*	Limit TFTP servers used for configuration file copies through SNMP to the servers in the access list. For *access-list-number*, enter an IP standard access list numbered from 1 to 99 and 1300 to 1999.
Step 3	**access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*]	Create a standard access list, repeating the command as many times as necessary. • For *access-list-number*, enter the access list number specified in Step 2. • The **deny** keyword denies access if the conditions are matched. The **permit** keyword permits access if the conditions are matched. • For *source*, enter the IP address of the TFTP servers that can access the switch. • (Optional) For *source-wildcard*, enter the wildcard bits, in dotted decimal notation, to be applied to the source. Place ones in the bit positions that you want to ignore. Recall that the access list is always terminated by an implicit deny statement for everything.

	Command	Purpose
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

SNMP Examples

This example shows how to enable all versions of SNMP. The configuration permits any SNMP manager to access all objects with read-only permissions using the community string *public*. This configuration does not cause the switch to send any traps.

```
Switch(config)# snmp-server community public
```

This example shows how to permit any SNMP manager to access all objects with read-only permission using the community string *public*. The switch also sends VTP traps to the hosts 192.180.1.111 and 192.180.1.33 using SNMPv1 and to the host 192.180.1.27 using SNMPv2C. The community string *public* is sent with the traps.

```
Switch(config)# snmp-server community public
Switch(config)# snmp-server enable traps vtp
Switch(config)# snmp-server host 192.180.1.27 version 2c public
Switch(config)# snmp-server host 192.180.1.111 version 1 public
Switch(config)# snmp-server host 192.180.1.33 public
```

This example shows how to allow read-only access for all objects to members of access list 4 that use the *comaccess* community string. No other SNMP managers have access to any objects. SNMP Authentication Failure traps are sent by SNMPv2C to the host *cisco.com* using the community string *public*.

```
Switch(config)# snmp-server community comaccess ro 4
Switch(config)# snmp-server enable traps snmp authentication
Switch(config)# snmp-server host cisco.com version 2c public
```

This example shows how to send Entity MIB traps to the host *cisco.com*. The community string is restricted. The first line enables the switch to send Entity MIB traps in addition to any traps previously enabled. The second line specifies the destination of these traps and overwrites any previous **snmp-server host** commands for the host *cisco.com*.

```
Switch(config)# snmp-server enable traps entity
Switch(config)# snmp-server host cisco.com restricted entity
```

This example shows how to enable the switch to send all traps to the host *myhost.cisco.com* using the community string *public*:

```
Switch(config)# snmp-server enable traps
Switch(config)# snmp-server host myhost.cisco.com public
```

Displaying SNMP Status

To display SNMP input and output statistics, including the number of illegal community string entries, errors, and requested variables, use the **show snmp** privileged EXEC command. You can also use the other privileged EXEC commands in Table 25-5 to display SNMP information. For information about the fields in the output displays, refer to the *Cisco IOS Configuration Fundamentals Command Reference for Release 12.1*.

Table 25-5 Commands for Displaying SNMP Information

Feature	Default Setting
show snmp	Displays SNMP statistics.
show snmp engineID [**local** | **remote**]	Displays information on the local SNMP engine and all remote engines that have been configured on the device.
show snmp group	Displays information on each SNMP group on the network.
show snmp user	Displays information on each SNMP user name in the SNMP users table.

CHAPTER 26

Configuring Network Security with ACLs

This chapter describes how to configure network security on a Catalyst 2950 or Catalyst 2955 switch by using access control lists (ACLs), which are also referred to in commands and tables as *access lists*.

You can create ACLs for physical interfaces or management interfaces. A management interface is defined as a management VLAN or any traffic that is going directly to the CPU, such as SNMP, Telnet, or web traffic. You can create ACLs for management interfaces with the standard software image (SI) or the enhanced software image (EI) installed on your switch. However, you must have the EI installed on your switch to apply ACLs to physical interfaces.

Note An ACLs that applied is to a physical interface has a limitation of one mask, and certain keywords are not supported. For more information, see the "Guidelines for Applying ACLs to Physical Interfaces" section on page 26-6.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release and the "Configuring IP Services" section of the *Cisco IOS IP and IP Routing Configuration Guide* and the *Command Reference for IOS Release 12.1*.

This chapter consists of these sections:

- Understanding ACLs, page 26-2
- Configuring ACLs, page 26-6
- Displaying ACL Information, page 26-21
- Examples for Compiling ACLs, page 26-23

You can configure ACLs by using the Cluster Management Suite (CMS) or through the command-line interface (CLI). Refer to the CMS online help for step-by-step configuration procedures through CMS. For information about accessing and using CMS, see Chapter 4, "Getting Started with CMS."

You can also use the security wizard to filter inbound traffic on the switches. Filtering can be based on network addresses, Transmission Control Protocol (TCP) applications, or User Datagram Protocol (UDP) applications. You can choose whether to drop or to forward packets that meet the filtering criteria. To use this wizard, you must know how the network is designed and how interfaces are used on the filtering device. Refer to the security wizard online help for step-by-step configuration procedures about using this wizard.

Understanding ACLs

Packet filtering can limit network traffic and restrict network use by certain users or devices. ACLs can filter traffic as it passes through a switch and permit or deny packets at specified interfaces. An ACL is a sequential collection of permit and deny conditions that apply to packets. When a packet is received on an interface, the switch compares the fields in the packet against any applied ACLs to verify that the packet has the required permissions to be forwarded, based on the criteria specified in the access lists. The switch tests the packet against the conditions in an access list one by one. The first match determines whether the switch accepts or rejects the packet. Because the switch stops testing conditions after the first match, the order of conditions in the list is critical. If no conditions match, the switch rejects the packet. If there are no restrictions, the switch forwards the packet; otherwise, the switch drops the packet.

You configure access lists on a Layer 2 switch to provide basic security for your network. If you do not configure ACLs, all packets passing through the switch could be allowed onto all parts of the network. You can use ACLs to control which hosts can access different parts of a network or to decide which types of traffic are forwarded or blocked at switch interfaces. For example, you can allow e-mail traffic to be forwarded but not Telnet traffic. ACLs can be configured to block inbound traffic.

An ACL contains an ordered list of access control entries (ACEs). Each ACE specifies *permit* or *deny* and a set of conditions the packet must satisfy in order to match the ACE. The meaning of *permit* or *deny* depends on the context in which the ACL is used.

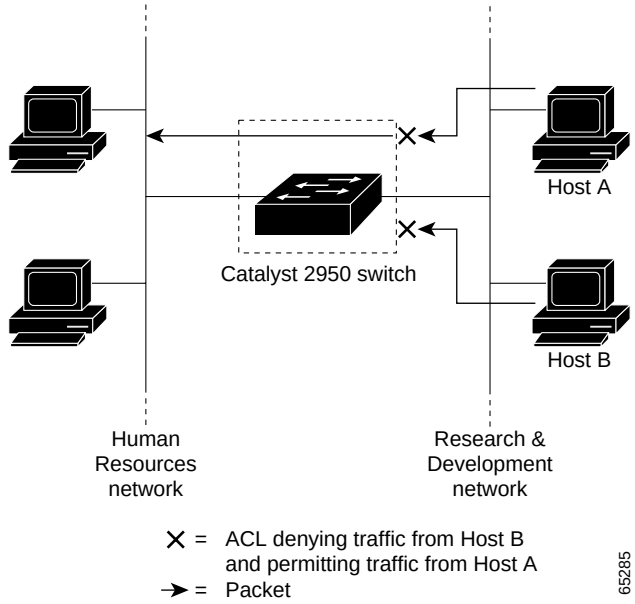
The switch supports these types of ACLs on physical interfaces in the inbound direction:

- IP ACLs filter IP, TCP, and UDP traffic.
- Ethernet or MAC ACLs filter Layer 2 traffic.
- MAC extended access lists use source and destination MAC addresses and optional protocol type information for matching operations.
- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses and optional protocol type information for matching operations.

The switch examines access lists associated with features configured on a given interface. As packets enter the switch on an interface, ACLs associated with all inbound features configured on that interface are examined.

ACLs permit or deny packet forwarding based on how the packet matches the entries in the ACL. For example, you can use ACLs to allow one host to access a part of a network, but to prevent another host from accessing the same part. In Figure 26-1, ACLs applied at the switch input allow Host A to access the Human Resources network, but prevent Host B from accessing the same network.

Figure 26-1 Using ACLs to Control Traffic to a Network



Handling Fragmented and Unfragmented Traffic

IP packets can be fragmented as they cross the network. When this happens, only the fragment containing the beginning of the packet contains the Layer 4 information, such as TCP or UDP port numbers, Internet Control Message Protocol (ICMP) type and code, and so on. All other fragments are missing this information.

Some ACEs do not check Layer 4 information and therefore can be applied to all packet fragments. ACEs that do test Layer 4 information cannot be applied in the standard manner to most of the fragments in a fragmented IP packet. When the fragment contains no Layer 4 information and the ACE tests some Layer 4 information, the matching rules are modified:

- Permit ACEs that check the Layer 3 information in the fragment (including protocol type, such as TCP, UDP, and so on) are considered to match the fragment regardless of what the missing Layer 4 information might have been.
- Deny ACEs that check Layer 4 information never match a fragment unless the fragment contains Layer 4 information.

Consider access list 102, configured with these commands, applied to three fragmented packets:

```
Switch (config)# access-list 102 permit tcp any host 10.1.1.1 eq smtp
Switch (config)# access-list 102 deny tcp any host 10.1.1.2 eq telnet
Switch (config)# access-list 102 deny tcp any any
```

Note In the first and second ACEs in the examples, the *eq* keyword after the destination address means to test for the TCP-destination-port well-known numbers equaling Simple Mail Transfer Protocol (SMTP) and Telnet, respectively.

- Packet A is a TCP packet from host 10.2.2.2, port 65000, going to host 10.1.1.1 on the SMTP port. If this packet is fragmented, the first fragment matches the first ACE (a permit), as if it were a complete packet because all Layer 4 information is present. The remaining fragments also match the first ACE, even though they do not contain the SMTP port information because the first ACE only checks Layer 3 information when applied to fragments. (The information in this example is that the packet is TCP and that the destination is 10.1.1.1.)
- Packet B is from host 10.2.2.2, port 65001, going to host 10.1.1.2 on the Telnet port. If this packet is fragmented, the first fragment matches the second ACE (a deny) because all Layer 3 and Layer 4 information is present. The remaining fragments in the packet do not match the second ACE because they are missing Layer 4 information.
- Because the first fragment was denied, host 10.1.1.2 cannot reassemble a complete packet, so packet B is effectively denied. However, the later fragments that are permitted will consume bandwidth on the network and the resources of host 10.1.1.2 as it tries to reassemble the packet.
- Fragmented packet C is from host 10.2.2.2, port 65001, going to host 10.1.1.3, port ftp. If this packet is fragmented, the first fragment matches the third ACE (a deny). All other fragments also match the third ACE because that ACE does not check any Layer 4 information and because Layer 3 information in all fragments shows that they are being sent to host 10.1.1.3, and the earlier permit ACEs were checking different hosts.

Understanding Access Control Parameters

Before configuring ACLs on the switches, you must have a thorough understanding of the access control parameters (ACPs). ACPs are referred to as *masks* in the switch CLI commands, output, and CMS.

Each ACE has a mask and a rule. The Classification Field or mask is the field of interest on which you want to perform an action. The specific values associated with a given mask are called *rules*.

Packets can be classified on these Layer 2, Layer 3, and Layer 4 fields:

- Layer 2 fields:
  - Source MAC address (Specify all 48 bits.)
  - Destination MAC address (Specify all 48 bits.)
  - Ethertype (16-bit ethertype field)

  You can use any combination or all of these fields simultaneously to define a flow.
- Layer 3 fields:
  - IP source address (Specify all 32 IP source address bits to define the flow, or specify an user-defined subnet. There are no restrictions on the IP subnet to be specified.)
  - IP destination address (Specify all 32 IP destination address bits to define the flow, or specify an user-defined subnet. There are no restrictions on the IP subnet to be specified.)

  You can use any combination or all of these fields simultaneously to define a flow.

- Layer 4 fields:
  - TCP (You can specify a TCP source, destination port number, or both at the same time.)
  - UDP (You can specify a UDP source, destination port number, or both at the same time.)

Note A mask can be a combination of either multiple Layer 3 and Layer 4 fields or of multiple Layer 2 fields. Layer 2 fields cannot be combined with Layer 3 or Layer 4 fields.

There are two types of masks:

- User-defined mask—masks that are defined by the user.
- System-defined mask—these masks can be configured on any interface:

```
Switch (config-ext-nacl)# permit tcp any any
Switch (config-ext-nacl)# deny tcp any any
Switch (config-ext-nacl)# permit udp any any
Switch (config-ext-nacl)# deny udp any any
Switch (config-ext-nacl)# permit ip any any
Switch (config-ext-nacl)# deny ip any any
Switch (config-ext-nacl)# deny any any
Switch (config-ext-nacl)# permit any any
```

Note In an IP extended ACL (both named and numbered), a Layer 4 system-defined mask cannot precede a Layer 3 user-defined mask. For example, a Layer 4 system-defined mask such as **permit tcp any any** or **deny udp any any** cannot precede a Layer 3 user-defined mask such as **permit ip 10.1.1.1 any**. If you configure this combination, the ACL is not allowed on a Layer 2 interface. All other combinations of system-defined and user-defined masks are allowed in security ACLs.

The switch ACL configuration is consistent with other Cisco Catalyst switches. However, there are significant restrictions for configuring ACLs on the switches.

Only four user-defined masks can be defined for the entire system. These can be used for either security or quality of service (QoS) but cannot be shared by QoS and security. You can configure as many ACLs as you require. However, a system error message appears if ACLs with more than four different masks are applied to interfaces. For more information about error messages, see the system message guide for this release.

Table 26-1 lists a summary of the ACL restrictions on the switches.

Table 26-1 Summary of ACL Restrictions

Restriction	Number Permitted
Number of user-defined masks allowed in an ACL	1
Number of ACLs allowed on an interface	1
Total number of user-defined masks for security and QoS allowed on a switch	4

Guidelines for Applying ACLs to Physical Interfaces

When applying ACLs to physical interfaces, follow these configuration guidelines:

- Only one ACL can be attached to an interface. For more information, refer to the **ip access-group** interface command in the command reference for this release.
- All ACEs in an ACL must have the same user-defined mask. However, ACEs can have different rules that use the same mask. On a given interface, only one type of user-defined mask is allowed, but you can apply any number of system-defined masks. For more information on system-defined masks, see the "Understanding Access Control Parameters" section on page 26-4.

  This example shows the same mask in an ACL:

  ```
  Switch (config)#ip access-list extended acl2
  Switch (config-ext-nacl)# permit tcp 10.1.1.1 0.0.0.0 any eq 80
  Switch (config-ext-nacl)# permit tcp 20.1.1.1 0.0.0.0 any eq 23
  ```

  In this example, the first ACE permits all the TCP packets coming from host 10.1.1.1 with a destination TCP port number of 80. The second ACE permits all TCP packets coming from host 20.1.1.1 with a destination TCP port number of 23. Both the ACEs use the same mask; therefore, a switch supports this ACL.
- When you apply an ACL to a physical interface, some keywords are not supported and certain mask restrictions apply to the ACLs. See the "Creating a Numbered Standard ACL" section on page 26-9 and the "Creating a Numbered Extended ACL" section on page 26-10 for creating these ACLs.

Note You can also apply ACLs to a management interface without the above limitations. For information, refer to the "Configuring IP Services" section of the *Cisco IOS IP and IP Routing Configuration Guide* and the *Command Reference for IOS Release 12.1*.

Configuring ACLs

This section includes these topics:

- "Unsupported Features" section on page 26-7
- "Creating Standard and Extended IP ACLs" section on page 26-7
- "Creating Named MAC Extended ACLs" section on page 26-18
- "Creating MAC Access Groups" section on page 26-19

Configuring ACLs on a Layer 2 interface is the same as configuring ACLs on Cisco routers. The process is briefly described here. For more detailed information about configuring router ACLs, refer to the "Configuring IP Services" chapter in the *Cisco IP and IP Routing Configuration Guide for IOS Release 12.1*. For detailed information about the commands, refer to the *Cisco IOS IP and IP Routing Command Reference for IOS Release 12.1*. For a list of IOS features not supported on the switch, see the "Unsupported Features" section on page 26-7.

Unsupported Features

The switch does not support these IOS router ACL-related features:

- Non-IP protocol ACLs (see Table 26-2 on page 26-8)
- Bridge-group ACLs
- IP accounting
- ACL support on the outbound direction
- Inbound and outbound rate limiting (except with QoS ACLs)
- IP packets that have a header length of less than 5 bytes
- Reflexive ACLs
- Dynamic ACLs (except for certain specialized dynamic ACLs used by the switch clustering feature)
- ICMP-based filtering
- Interior Gateway Routing Protocol (IGMP)-based filtering

Creating Standard and Extended IP ACLs

This section describes how to create switch IP ACLs. The switch tests packets against the conditions in an access list one by one. The first match determines whether the switch accepts or rejects the packet. Because the switch stops testing conditions after the first match, the order of the conditions is critical. If no conditions match, the switch denies the packet.

Follow these steps to use ACLs:

Step 1 Create an ACL by specifying an access list number or name and access conditions.

Step 2 Apply the ACL to interfaces or terminal lines.

The software supports these kinds of IP access lists:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses for matching operations and optional protocol-type information for finer granularity of control.

Note MAC extended access list use source and destination MAC addresses and optional protocol type information for matching operations. For more information, see the "Creating Named MAC Extended ACLs" section on page 26-18.

The next sections describe access lists and the steps for using them.

ACL Numbers

The number you use to denote your ACL shows the type of access list that you are creating. Table 26-2 lists the access list number and corresponding type and shows whether or not they are supported by the switch. The switch supports IP standard and IP extended access lists, numbers 1 to 199 and 1300 to 2699.

Table 26-2 Access List Numbers

ACL Number	Type	Supported
1–99	IP standard access list	Yes
100–199	IP extended access list	Yes
200–299	Protocol type-code access list	No
300–399	DECnet access list	No
400–499	XNS standard access list	No
500–599	XNS extended access list	No
600–699	AppleTalk access list	No
700–799	48-bit MAC address access list	No
800–899	IPX standard access list	No
900–999	IPX extended access list	No
1000–1099	IPX SAP access list	No
1100–1199	Extended 48-bit MAC address access list	No
1200–1299	IPX summary address access list	No
1300–1999	IP standard access list (expanded range)	Yes
2000–2699	IP extended access list (expanded range)	Yes

Note In addition to numbered standard and extended ACLs, you can also create named standard and extended IP ACLs by using the supported numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Creating a Numbered Standard ACL

Note For information about creating ACLs to apply to a management interface, refer to the "Configuring IP Services" section of the *Cisco IOS IP and IP Routing Configuration Guide* and the *Command Reference for IOS Release 12.1*. You can these apply these ACLs only to a management interface.

Beginning in privileged EXEC mode, follow these steps to create a numbered standard IP ACL:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list** *access-list-number* {**deny** | **permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**}	Define a standard IP ACL by using a source address and wildcard. The *access-list-number* is a decimal number from 1 to 99 or 1300 to 1999. Enter **deny** or **permit** to specify whether to deny or permit access if conditions are matched. The *source* is the source address of the network or host from which the packet is being sent: • The 32-bit quantity in dotted-decimal format. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. You do not need to enter a source wildcard. • The keyword **host** as an abbreviation for *source* and *source-wildcard* of *source* 0.0.0.0. (Optional) The *source-wildcard* applies wildcard bits to the source. (See first bullet item.) **Note** The **log** option is not supported on the switches.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show access-lists** [*number* | *name*]	Show the access list configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no access-list** *access-list-number* global configuration command to delete the entire ACL. You cannot delete individual ACEs from numbered access lists.

Note When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the mask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

This example shows how to create a standard ACL to deny access to IP host 171.69.198.102, permit access to any others, and display the results.

```
Switch (config)# access-list 2 deny host 171.69.198.102
Switch (config)# access-list 2 permit any
Switch(config)# end
Switch# show access-lists
Standard IP access list 2
    deny   171.69.198.102
    permit any
```

Creating a Numbered Extended ACL

Although standard ACLs use only source addresses for matching, you can use an extended ACL source and destination addresses for matching operations and optional protocol type information for finer granularity of control. Some protocols also have specific parameters and keywords that apply to that protocol.

These IP protocols are supported on physical interfaces (protocol keywords are in parentheses in bold): Internet Protocol (**ip**), Transmission Control Protocol (**tcp**), or User Datagram Protocol (**udp**).

Supported parameters can be grouped into these categories:

- TCP
- UDP

Table 26-3 lists the possible filtering parameters for ACEs for each protocol type.

Table 26-3 Filtering Parameter ACEs Supported by Different IP Protocols

Filtering Parameter[1]	TCP	UDP
Layer 3 Parameters:		
IP type of service (ToS) byte[2]	–	–
Differentiated Services Code Point (DSCP)	X	X
IP source address	X	X
IP destination address	X	X
Fragments	–	–
TCP or UDP	X	X
Layer 4 Parameters		
Source port operator	X	X
Source port	X	X
Destination port operator	X	X
Destination port	X	X
TCP flag	–	–

1. X in a protocol column means support for the filtering parameter.
2. No support for type of service (ToS) minimize monetary cost bit.

For more details about the specific keywords relative to each protocol, refer to the *Cisco IP and IP Routing Command Reference for IOS Release 12.1*.

Note The switch does not support dynamic or reflexive access lists. It also does not support filtering based on the minimize-monetary-cost type of service (ToS) bit.

When creating ACEs in numbered extended access lists, remember that after you create the list, any additions are placed at the end of the list. You cannot reorder the list or selectively add or remove ACEs from a numbered list.

Note For information about creating ACLs to apply to management interfaces, refer to the "Configuring IP Services" section of *Cisco IOS IP and IP Routing Configuration Guide* and the *Command Reference for IOS Release 12.1*. You can apply ACLs only to a management interface or the CPU, such as SNMP, Telnet, or web traffic.

Beginning in privileged EXEC mode, follow these steps to create an extended ACL:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list** *access-list-number* {**deny** | **permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] [**dscp** *dscp-value*] [**time-range** *time-range-name*]	Define an extended IP access list and the access conditions. The *access-list-number* is a decimal number from 100 to 199 or 2000 to 2699. Enter **deny** or **permit** to specify whether to deny or permit the packet if conditions are matched. For *protocol*, enter the name or number of an IP protocol: IP, TCP, or UDP. To match any Internet protocol (including TCP and UDP), use the keyword **ip**. The *source* is the number of the network or host from which the packet is sent. The *source-wildcard* applies wildcard bits to the source. The *destination* is the network or host number to which the packet is sent. Define a destination or source port. • The *operator* can be only **eq** (equal). • If operator is after *source source-wildcard*, conditions match when the source port matches the defined port. • If operator is after *destination destination-wildcard*, conditions match when the destination port matches the defined port. • The *port* is a decimal number or name of a TCP or UDP port. The number can be from 0 to 65535. • Use TCP port names only for TCP traffic. • Use UDP port names only for UDP traffic. The *destination-wildcard* applies wildcard bits to the destination. *Source*, *source-wildcard*, *destination*, and *destination-wildcard* can be specified in three ways: • The 32-bit quantity in dotted-decimal format. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255 or any source host. • The keyword **host,** followed by the 32-bit quantity in dotted-decimal format, as an abbreviation for a single host with *source* and *source-wildcard* of *source* 0.0.0.0. **dscp**—Enter to match packets with any of the supported 13 DSCP values (0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56), or use the question mark (**?**) to see a list of available values. The **time-range** keyword is optional. For an explanation of this keyword, see the "Applying Time Ranges to ACLs" section on page 26-15.
Step 3	**show access-lists** [*number* | *name*]	Verify the access list configuration.
Step 4	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no access-list** *access-list-number* global configuration command to delete the entire access list. You cannot delete individual ACEs from numbered access lists.

This example shows how to create and display an extended access list to deny Telnet access from any host in network 171.69.198.0 to any host in network 172.20.52.0 and permit any others. (The **eq** keyword after the destination address means to test for the TCP destination port number equaling Telnet.)

```
Switch(config)# access-list 102 deny tcp 171.69.198.0 0.0.0.255 172.20.52.0 0.0.0.255 eq
telnet
Switch(config)# access-list 102 permit tcp any any
Switch(config)# end
Switch# show access-lists
Extended IP access list 102
    deny tcp 171.69.198.0 0.0.0.255 172.20.52.0 0.0.0.255 eq telnet
    permit tcp any any
```

After an ACL is created, any additions (possibly entered from the terminal) are placed at the end of the list. You can add ACEs to an ACL, but deleting any ACE deletes the entire ACL.

Note When creating an ACL, remember that, by default, the end of the access list contains an implicit deny statement for all packets if the access list does not find a match before reaching the end. With standard access lists, if you omit the mask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

After creating an ACL, you must apply it to a line or interface, as described in the "Applying ACLs to Terminal Lines or Physical Interfaces" section on page 26-20.

Creating Named Standard and Extended ACLs

You can identify IP ACLs with an alphanumeric string (a name) rather than a number. You can use named ACLs to configure more IP access lists on a switch than if you use numbered access lists. If you identify your access list with a name rather than a number, the mode and command syntax are slightly different. However, not all commands that use IP access lists accept a named ACL.

Note The name you give to a standard ACL or extended ACL can also be a number in the supported range of access list numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Consider these guidelines and limitations before configuring named ACLs:

- A standard ACL and an extended ACL cannot have the same name.
- Numbered ACLs are also available, as described in the "Creating Standard and Extended IP ACLs" section on page 26-7.

Beginning in privileged EXEC mode, follow these steps to create a standard named access list using names:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip access-list standard** {*name* | *access-list-number*}	Define a standard IP access list by using a name, and enter access-list configuration mode. **Note** The name can be a number from 1 to 99.
Step 3	**deny** {*source source-wildcard* | **host** *source* | **any**} or **permit** {*source source-wildcard* | **host** *source* | **any**}	In access-list configuration mode, specify one or more conditions denied or permitted to determine if the packet is forwarded or dropped. • **host** *source* represents a *source* and *source-wildcard* of *source* 0.0.0.0. • **any** represents a *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. **Note** The **log** option is not supported on the switches.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show access-lists** [*number* | *name*]	Show the access list configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Beginning in privileged EXEC mode, follow these steps to create an extended named ACL using names:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip access-list extended** {*name* | *access-list-number*}	Define an extended IP access list by using a name, and enter access-list configuration mode. **Note** The name can be a number from 100 to 199.
Step 3	{**deny** | **permit**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] [**dscp** *dscp-value*] [**time-range** *time-range-name*]	In access-list configuration mode, specify the conditions allowed or denied. See the "Creating a Numbered Extended ACL" section on page 26-10 for definitions of protocols and other keywords. • **host** *source* represents a *source* and *source-wildcard* of *source* 0.0.0.0, and **host** *destination* represents a *destination* and *destination-wildcard* of *destination* 0.0.0.0. • **any** represents a *source* and *source-wildcard* or *destination* and *destination-wildcard* of 0.0.0.0 255.255.255.255. **dscp**—Enter to match packets with any of the supported 13 DSCP values (0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56), or use the question mark (**?**) to see a list of available values. The **time-range** keyword is optional. For an explanation of this keyword, see the "Applying Time Ranges to ACLs" section on page 26-15.
Step 4	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 5	**show access-lists** [*number* | *name*]	Show the access list configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

When making the standard and extended ACL, remember that, by default, the end of the ACL contains an implicit deny statement for everything if it did not find a match before reaching the end. For standard ACLs, if you omit the mask from an associated IP host address access list specification, 0.0.0.0 is assumed to be the mask.

After you create an ACL, any additions are placed at the end of the list. You cannot selectively add ACEs to a specific ACL. However, you can use **no permit** and **no deny** commands to remove ACEs from a named ACL. This example shows how you can delete individual ACEs from a named ACL:

```
Switch(config)# ip access-list extended border-list
Switch(config-ext-nacl)# no permit ip host 10.1.1.3 any
```

Being able to selectively remove lines from a named ACL is one reason you might use named ACLs instead of numbered ACLs.

After creating an ACL, you must apply it to a line or interface, as described in the "Applying ACLs to Terminal Lines or Physical Interfaces" section on page 26-20.

Applying Time Ranges to ACLs

You can implement extended ACLs based on the time of day and week by using the **time-range** global configuration command. First, define the name and times of the day and week of the time range, and then reference the time range by name in an ACL to apply restrictions to the access list. You can use the time range to define when the permit or deny statements in the ACL are in effect. The **time-range** keyword and argument are referenced in the named and numbered extended ACL task tables in the "Creating Standard and Extended IP ACLs" section on page 26-7, and the "Creating Named Standard and Extended ACLs" section on page 26-13.

These are some of the many benefits of using time ranges:

- You have more control over permitting or denying a user access to resources, such as an application (identified by an IP address mask pair and a port number).
- You can control logging messages. ACL entries can log traffic at certain times of the day, but not constantly. Therefore, you can simply deny access without having to analyze many logs generated during peak hours.

Note The time range relies on the switch system clock. Therefore, you need a reliable clock source. We recommend that you use Network Time Protocol (NTP) to synchronize the switch clock. For more information, see the "Managing the System Time and Date" section on page 8-1.

Beginning in privileged EXEC mode, follow these steps to configure a time-range parameter for an ACL:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**time-range** *time-range-name*	Identify the time-range by a meaningful name (for example, *workhours*), and enter time-range configuration mode. The name cannot contain a space or quotation mark and must begin with a letter.

	Command	Purpose
Step 3	**absolute** [**start** *time date*] [**end** *time date*] or **periodic** *day-of-the-week hh:mm to* [*day-of-the-week*] *hh:mm* or **periodic** {**weekdays** | **weekend** | **daily**} *hh:mm to hh:mm*	Specify when the function it will be applied to is operational. Use some combination of these commands; multiple **periodic** statements are allowed; only one **absolute** statement is allowed. If more than one absolute statement is configured, only the one configured last is executed.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show time-range**	Verify the time-range configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a configured time-range, use the **no time-range** *time-range-name* global configuration command.

Repeat the steps if you have multiple items that you want operational at different times.

This example shows how to configure time ranges for *workhours* and for company holidays and how to verify your configuration.

```
Switch(config)# time-range workhours
Switch(config-time-range)# periodic weekdays 8:00 to 12:00
Switch(config-time-range)# periodic weekdays 13:00 to 17:00
Switch(config-time-range)# exit
Switch(config)# time-range new_year_day_2000
Switch(config-time-range)# absolute start 00:00 1 Jan 2000 end 23:59 1 Jan 2000
Switch(config-time-range)# exit
Switch(config)# time-range thanksgiving_2000
Switch(config-time-range)# absolute start 00:00 22 Nov 2000 end 23:59 23 Nov 2000
Switch(config-time-range)# exit
Switch(config)# time-range christmas_2000
Switch(config-time-range)# absolute start 00:00 24 Dec 2000 end 23:50 25 Dec 2000
Switch(config-time-range)# end
Switch# show time-range
time-range entry: christmas_2000 (inactive)
   absolute start 00:00 24 December 2000 end 23:50 25 December 2000
time-range entry: new_year_day_2000 (inactive)
   absolute start 00:00 01 January 2000 end 23:59 01 January 2000
time-range entry: thanksgiving_2000 (inactive)
   absolute start 00:00 22 November 2000 end 23:59 23 November 2000
time-range entry: workhours (inactive)
   periodic weekdays 8:00 to 12:00
   periodic weekdays 13:00 to 17:00
```

To apply a time range, you must reference it by name (for example, *workhours*) in an extended ACL that can implement time ranges. This example shows how to create and verify extended access list 188 that denies TCP traffic from any source to any destination during the defined holiday time ranges and permits all TCP traffic during work hours.

```
Switch(config)# access-list 188 deny tcp any any time-range new_year_day_2000
Switch(config)# access-list 188 deny tcp any any time-range thanskgiving_2000
Switch(config)# access-list 188 deny tcp any any time-range christmas_2000
Switch(config)# access-list 188 permit tcp any any time-range workhours
Switch(config)# end
```

```
Switch# show access-lists
Extended IP access list 188
    deny tcp any any time-range new_year_day_2000 (inactive)
    deny tcp any any time-range thanskgiving_2000 (active)
    deny tcp any any time-range christmas_2000 (inactive)
    permit tcp any any time-range workhours (inactive)
```

This example uses named ACLs to permit and deny the same traffic.

```
Switch(config)# ip access-list extended deny_access
Switch(config-ext-nacl)# deny tcp any any time-range new_year_day_2000
Switch(config-ext-nacl)# deny tcp any any time-range thanksgiving_2000
Switch(config-ext-nacl)# deny tcp any any time-range christmas_2000
Switch(config-ext-nacl)# exit
Switch(config)# ip access-list extended may_access
Switch(config-ext-nacl)# permit tcp any any time-range workhours
Switch(config-ext-nacl)# end
Switch# show ip access-lists
Extended IP access list deny_access
    deny tcp any any time-range new_year_day_2000 (inactive)
    deny tcp any any time-range thanksgiving_2000 (inactive)
    deny tcp any any time-range christmas_2000 (inactive)
Extended IP access list may_access
    permit tcp any any time-range workhours (inactive)
```

Including Comments About Entries in ACLs

You can use the **remark** command to include comments (remarks) about entries in any IP standard or extended ACL. The remarks make the ACL easier for you to understand and scan. Each remark line is limited to 100 characters.

The remark can go before or after a permit or deny statement. You should be consistent about where you put the remark so that it is clear which remark describes which permit or deny statement. For example, it would be confusing to have some remarks before the associated permit or deny statements and some remarks after the associated statements.

For IP numbered standard or extended ACLs, use the **access-list** *access-list number* **remark** *remark* global configuration command to include a comment about an access list. To remove the remark, use the **no** form of this command.

In this example, the workstation belonging to Jones is allowed access, and the workstation belonging to Smith is not allowed access:

```
Switch(config)# access-list 1 remark Permit only Jones workstation through
Switch(config)# access-list 1 permit 171.69.2.88
Switch(config)# access-list 1 remark Do not allow Smith workstation through
Switch(config)# access-list 1 deny 171.69.3.13
```

For an entry in a named IP ACL, use the **remark** access-list global configuration command. To remove the remark, use the **no** form of this command.

In this example, the Jones subnet is not allowed to use outbound Telnet:

```
Switch(config)# ip access-list extended telnetting
Switch(config-ext-nacl)# remark Do not allow Jones subnet to telnet out
Switch(config-ext-nacl)# deny tcp host 171.69.2.88 any eq telnet
```

Creating Named MAC Extended ACLs

You can filter Layer 2 traffic on a physical Layer 2 interface by using MAC addresses and named MAC extended ACLs. The procedure is similar to that of configuring other extended named access lists.

Note Named MAC extended ACLs are used as a part of the **mac access-group** privileged EXEC command.

For more information about the supported non-IP protocols in the **mac access-list extended** command, refer to the command reference for this release.

Note Matching on any SNAP-encapsulated packet with a nonzero Organizational Unique Identifier (OUI) is not supported.

Beginning in privileged EXEC mode, follow these steps to create a named MAC extended ACL:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mac access-list extended** *name*	Define an extended MAC access list by using a name.
Step 3	{**deny** | **permit**} {**any** | **host** *source MAC address*} {**any** | **host** *destination MAC address*} [**aarp** | **amber | appletalk** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** |**vines-ip** | **xns-idp**]	In extended MAC access-list configuration mode, specify to **permit** or **deny any** source MAC address or a specific **host** source MAC address and **any** destination MAC address. (Optional) You can also enter these options: **aarp** | **amber | appletalk** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** |**vines-ip** | **xns-idp**—(a non-IP protocol).
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show access-lists** [*number* | *name*]	Show the access list configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no mac access-list extended** *name* global configuration command to delete the entire ACL. You can also delete individual ACEs from named MAC extended ACLs.

This example shows how to create and display an access list named *mac1*, denying only EtherType DECnet Phase IV traffic, but permitting all other types of traffic.

```
Switch(config)# mac access-list extended mac1
Switch(config-ext-macl)# deny any any decnet-iv
Switch(config-ext-macl)# permit any any
Switch(config-ext-macl)# end
Switch # show access-list
Extended MAC access list mac1
    deny   any any decnet-iv
    permit any any
```

Creating MAC Access Groups

Beginning in privileged EXEC mode, follow these steps to create MAC access groups and to apply a MAC access list to an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Identify a specific interface for configuration, and enter interface configuration mode. The interface must be a Layer 2 interface.
Step 3	**mac access-group** {*name*} {**in**}	Control access to the specified interface by using the MAC access list name.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show mac-access group**	Display the MAC ACLs applied on the switch.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to apply ACL 2 on Gigabit Ethernet interface 0/1 to filter packets entering the interface:

```
Switch(config)# interface gigabitethernet0/1
Router(config-if)# mac access-group 2 in
```

Note The **mac access-group** interface configuration command is only valid when applied to a Layer 2 interface.

For inbound ACLs, after receiving a packet, the switch checks the packet against the ACL. If the ACL permits the packet, the switch continues to process the packet. If the ACL rejects the packet, the switch discards the packet. The MAC ACL applies to both IP and non-IP packets.

When you apply an undefined ACL to an interface, the switch acts as if the ACL has not been applied to the interface and permits all packets. Remember this behavior if you use undefined ACLs as a means of network security.

Applying ACLs to Terminal Lines or Physical Interfaces

Note Before applying an ACL to a physical interface, see the "Guidelines for Applying ACLs to Physical Interfaces" section on page 26-6.

You can apply ACLs to any management interface. For information on creating ACLs on management interfaces, refer to the "Configuring IP Services" section of the *Cisco IOS IP and IP Routing Configuration Guide* and the *Command Reference for IOS Release 12.1*.

Note The limitations that apply to ACLs on physical interfaces do not apply to ACLs on management interfaces.

After you create an ACL, you can apply it to one or more management interfaces or terminal lines. ACLs can be applied on inbound interfaces. This section describes how to accomplish this task for both terminal lines and network interfaces. Note these guidelines:

- When controlling access to a line, you must use numbered IP ACLs or MAC extended ACLs.
- When controlling access to an interface, you can use named or numbered ACLs.
- Set identical restrictions on all the virtual terminal lines because a user can attempt to connect to any of them.
- If you apply ACLs to a management interface, the ACL only filters packets that are intended for the CPU, such as SNMP, Telnet, or web traffic.
- If you apply ACLs to a management VLAN, see the "Management VLAN" section on page 7-19.

Applying ACLs to a Terminal Line

Beginning in privileged EXEC mode, follow these steps to restrict incoming connections between a virtual terminal line and the addresses in an ACL:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**line** [**console** | **vty**] *line-number*	Identify a specific line for configuration, and enter in-line configuration mode. Enter **console** for the console terminal line. The console port is DCE. Enter **vty** for a virtual terminal for remote console access. The *line-number* is the first line number in a contiguous group that you want to configure when the line type is specified. The range is from 0 to 16.
Step 3	**access-class** *access-list-number* {**in**}	Restrict incoming and outgoing connections between a particular virtual terminal line (into a device) and the addresses in an access list.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Display the access list configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Applying ACLs to a Physical Interface

Beginning in privileged EXEC mode, follow these steps to control access to a Layer 2 interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Identify a specific interface for configuration and enter interface configuration mode. The interface must be a Layer 2 or management interface or a management interface VLAN ID.
Step 3	**ip access-group** {*access-list-number* | *name*} {**in**}	Control access to the specified interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Display the access list configuration.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

This example shows how to apply access list 2 on Gigabit Ethernet interface 0/2 to filter packets entering the interface:

```
Switch(config)# interface gigabitethernet0/2
Router(config-if)# ip access-group 2 in
```

Note The **ip access-group** interface configuration command is only valid when applied to a management interface or a Layer 2 physical interface. ACLs cannot be applied to interface port-channels.

For inbound ACLs, after receiving a packet, the switch checks the packet against the ACL. If the ACL permits the packet, the switch continues to process the packet. If the ACL rejects the packet, the switch discards the packet.

When you apply an undefined ACL to an interface, the switch acts as if the ACL has not been applied to the interface and permits all packets. Remember this behavior if you use undefined ACLs for network security.

Displaying ACL Information

You can display the ACLs that are configured on the switch, and you can display the ACLs that have been applied to physical and management interfaces. This section consists of these topics:

- Displaying ACLs, page 26-22
- Displaying Access Groups, page 26-23

Displaying ACLs

You can display existing ACLs by using **show** commands.

Beginning in privileged EXEC mode, follow these steps to display access lists:

	Command	Purpose
Step 1	**show access-lists** [*number* | *name*]	Show information about all IP and MAC address access lists or about a specific access list (numbered or named).
Step 2	**show ip access-list** [*number* | *name*]	Show information about all IP address access lists or about a specific IP ACL (numbered or named).

This example shows all standard and extended ACLs:

```
Switch# show access-lists
Standard IP access list 1
    permit 172.20.10.10
Standard IP ACL 10
    permit 12.12.12.12
Standard IP access list 12
    deny   1.3.3.2
Standard IP access list 32
    permit 172.20.20.20
Standard IP access list 34
    permit 10.24.35.56
    permit 23.45.56.34
Extended IP access list 120
Extended MAC access list mac1
```

This example shows only IP standard and extended ACLs.

```
Switch# show ip access-lists
Standard IP access list 1
    permit 172.20.10.10
Standard IP access list 10
    permit 12.12.12.12
Standard IP access list 12
    deny   1.3.3.2
Standard IP access list 32
    permit 172.20.20.20
Standard IP access list 34
    permit 10.24.35.56
    permit 23.45.56.34
Extended IP access list 120
```

Displaying Access Groups

Note This feature is available only if your switch is running the EI.

You use the **ip access-group** interface configuration command to apply ACLs to a Layer 3 interface. When IP is enabled on an interface, you can use the **show ip interface** *interface-id* privileged EXEC command to view the input and output access lists on the interface, as well as other interface characteristics. If IP is not enabled on the interface, the access lists are not shown.

This example shows how to view all access groups configured for VLAN 1 and for Gigabit Ethernet interface 0/2:

```
Switch# show ip interface vlan 1
GigabitEthernet0/2 is up, line protocol is down
  Internet address is 10.20.30.1/16
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is permit Any
  Inbound  access list is 13

<information truncated>

Switch# show ip interface fastethernet0/9
FastEthernet0/9 is down, line protocol is down
  Inbound  access list is ip1
```

The only way to ensure that you can view all configured access groups under all circumstances is to use the **show running-config** privileged EXEC command. To display the ACL configuration of a single interface, use the **show running-config interface** *interface-id* command.

This example shows how to display the ACL configuration of Gigabit Ethernet interface 0/1:

```
Switch# show running-config interface gigabitethernet0/1
Building configuration...

Current configuration :112 bytes
!
interface GigabitEthernet0/1
 ip access-group 11 in
 snmp trap link-status
 no cdp enable
end!
```

Examples for Compiling ACLs

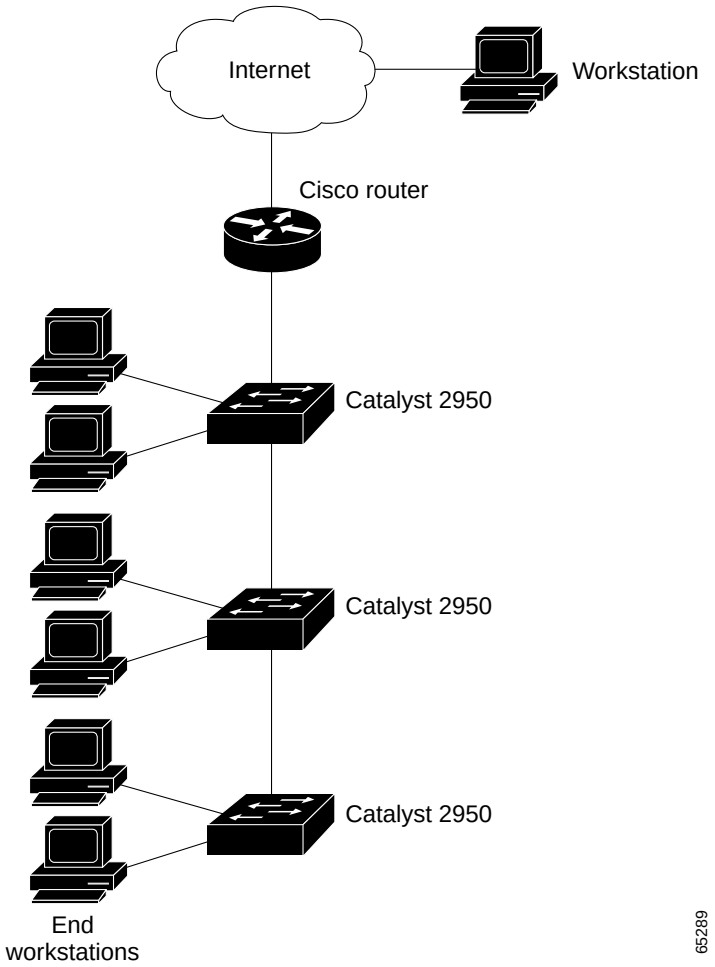
For detailed information about compiling ACLs, refer to the *Security Configuration Guide* and the "IP Services" chapter of the *Cisco IOS IP and IP Routing Configuration Guide for IOS Release 12.1.*

Figure 26-2 shows a small networked office with a stack of switches that are connected to a Cisco router. A host is connected to the network through the Internet using a WAN link.

Use switch ACLs to do these:

- Create a standard ACL, and filter traffic from a specific Internet host with an address 172.20.128.64.
- Create an extended ACL, and filter traffic to deny HTTP access to all Internet hosts but allow all other types of access.

Figure 26-2 Using Switch ACLs to Control Traffic



This example uses a standard ACL to allow access to a specific Internet host with the address 172.20.128.64.

```
Switch(config)# access-list 6 permit 172.20.128.64 0.0.0.0
Switch(config)# end
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# ip access-group 6 in
```

This example uses an extended ACL to deny traffic from port 80 (HTTP). It permits all other types of traffic.

```
Switch(config)# access-list 106 deny tcp any any eq 80
Switch(config)# access-list 106 permit ip any any
Switch(config)# interface gigabitethernet0/2
Switch(config-if)# ip access-group 106 in
```

Numbered ACL Examples

This example shows that the switch accepts addresses on network 36.0.0.0 subnets and denies all packets coming from 56.0.0.0 subnets. The ACL is then applied to packets entering Gigabit Ethernet interface 0/1.

```
Switch(config)# access-list 2 permit 36.0.0.0 0.255.255.255
Switch(config)# access-list 2 deny 56.0.0.0 0.255.255.255
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# ip access-group 2 in
```

Extended ACL Examples

In this example of using an extended ACL, you have a network connected to the Internet, and you want any host on the network to be able to form TCP Telnet and SMTP connections to any host on the Internet.

```
Switch(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 eq 23
Switch(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 eq 25
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# ip access-group 102 in
```

SMTP uses TCP port 25 on one end of the connection and a random port number on the other end. The same port numbers are used throughout the life of the connection. Mail packets coming in from the Internet have a destination port of 25. Because the secure system behind the switch always accepts mail connections on port 25, the incoming services are controlled.

Named ACL Example

The Marketing_group ACL allows any TCP Telnet traffic to the destination address and wildcard 171.69.0.0 0.0.255.255 and denies any other TCP traffic. It permits any other IP traffic.

```
Switch(config)# ip access-list extended marketing_group
Switch(config-ext-nacl)# permit tcp any 171.69.0.0 0.0.255.255 eq telnet
Switch(config-ext-nacl)# deny tcp any any
Switch(config-ext-nacl)# permit ip any any
```

The ACLs are applied to permit Gigabit Ethernet port 0/1, which is configured as a Layer 2 port, with the Marketing_group ACL applied to incoming traffic.

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# ip access-group marketing_group in
...
```

Commented IP ACL Entry Examples

In this example of a numbered ACL, the workstation belonging to Jones is allowed access, and the workstation belonging to Smith is not allowed access:

```
Switch(config)# access-list 1 remark Permit only Jones workstation through
Switch(config)# access-list 1 permit 171.69.2.88
Switch(config)# access-list 1 remark Do not allow Smith workstation through
Switch(config)# access-list 1 deny 171.69.3.13
```

In this example of a numbered ACL, the Winter and Smith workstations are not allowed to browse the web:

```
Switch(config)# access-list 100 remark Do not allow Winter to browse the web
Switch(config)# access-list 100 deny host 171.69.3.85 any eq www
Switch(config)# access-list 100 remark Do not allow Smith to browse the web
Switch(config)# access-list 100 deny host 171.69.3.13 any eq www
```

In this example of a named ACL, the Jones subnet is not allowed access:

```
Switch(config)# ip access-list standard prevention
Switch(config-std-nacl)# remark Do not allow Jones subnet through
Switch(config-std-nacl)# deny 171.69.0.0 0.0.255.255
```

In this example of a named ACL, the Jones subnet is not allowed to use outbound Telnet:

```
Switch(config)# ip access-list extended telnetting
Switch(config-ext-nacl)# remark Do not allow Jones subnet to telnet out
Switch(config-ext-nacl)# deny tcp 171.69.0.0 0.0.255.255 any eq telnet
```

CHAPTER 27

Configuring QoS

This chapter describes how to configure quality of service (QoS) by using automatic-QoS (auto-QoS) commands or by using standard QoS commands. With QoS, you can give preferential treatment to certain types of traffic at the expense of others. Without QoS, the Catalyst 2950 or Catalyst 2955 switch offers best-effort service to each packet, regardless of the packet contents or size. It sends the packets without any assurance of reliability, delay bounds, or throughput.

To use the features described in this chapter, you must have the enhanced software image (EI) installed on your switch.

If you have the standard software image (SI) installed on your switch, you cannot configure some of the features. Table 27-1 lists the sections that describe the features that you can configure.

Table 27-1 Sections Describing Standard Software Features

Topic	Section
Queueing and scheduling at the egress ports	"Queueing and Scheduling" section on page 27-8
Configuring QoS	"Configuring Standard QoS" section on page 27-15
	"Default Standard QoS Configuration" section on page 27-16
	"Configuring Classification Using Port Trust States" section on page 27-17
	"Configuring the Egress Queues" section on page 27-34

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

QoS can be configured either by using the Cluster Management Suite (CMS) or through the command-line interface (CLI). Refer to the CMS online help for configuration procedures through CMS. For information about accessing and using CMS, see Chapter 4, "Getting Started with CMS."

You can also use these wizards to configure QoS only if your switch is running the EI:

- Priority data wizard—Lets you assign priority levels to data applications based on their TCP or UDP ports. It has a standard list of applications, and you select the ones that you want to prioritize, the priority levels, and the interfaces where the prioritization occurs. Refer to the priority data wizard online help for procedures about using this wizard.
- Video wizard—Gives traffic that originates from specified video servers a higher priority than the priority of data traffic. The wizard assumes that the video servers are connected to a single device in the cluster. Refer to the video wizard online help for procedures about using this wizard.

This chapter consists of these sections:

- Understanding QoS, page 27-2
- Configuring Auto-QoS, page 27-9
- Displaying Auto-QoS Information, page 27-13
- Auto-QoS Configuration Example, page 27-14
- Configuring Standard QoS, page 27-15
- Displaying Standard QoS Information, page 27-36
- Standard QoS Configuration Examples, page 27-36

Understanding QoS

This section describes how QoS is implemented on the switch. If you have the SI installed on your switch, some concepts and features in this section might not apply. For a list of available features, see Table 27-1 on page 27-1.

Typically, networks operate on a best-effort delivery basis, which means that all traffic has equal priority and an equal chance of being delivered in a timely manner. When congestion occurs, all traffic has an equal chance of being dropped.

When you configure the QoS feature, you can select specific network traffic, prioritize it according to its relative importance, and use congestion-management and congestion-avoidance techniques to give preferential treatment. Implementing QoS in your network makes network performance more predictable and bandwidth utilization more effective.

The QoS implementation is based on the DiffServ architecture, an emerging standard from the Internet Engineering Task Force (IETF). This architecture specifies that each packet is classified upon entry into the network. The classification is carried in the IP packet header, using 6 bits from the deprecated IP type-of-service (ToS) field to carry the classification (*class*) information.

Classification can also be carried in the Layer 2 frame. These special bits in the Layer 2 frame or a Layer 3 packet are described here and shown in Figure 27-1:

- Prioritization values in Layer 2 frames

  Layer 2 802.1Q frame headers have a 2-byte Tag Control Information field that carries the class of service (CoS) value in the three most-significant bits, which are called the User Priority bits. On interfaces configured as Layer 2 802.1Q trunks, all traffic is in 802.1Q frames except for traffic in the native VLAN.

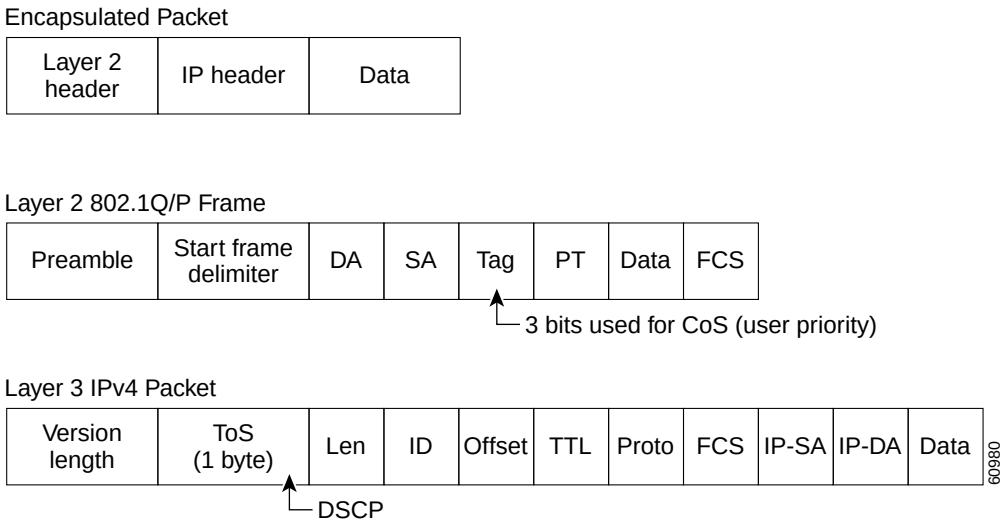
  Other frame types cannot carry Layer 2 CoS values.

  Layer 2 CoS values range from 0 for low priority to 7 for high priority.

- Prioritization bits in Layer 3 packets

  Layer 3 IP packets can carry a Differentiated Services Code Point (DSCP) value. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.

Figure 27-1 QoS Classification Layers in Frames and Packets



All switches and routers that access the Internet rely on the class information to give the same forwarding treatment to packets with the same class information and different treatment to packets with different class information. The class information in the packet can be assigned by end hosts or by switches or routers along the way, based on a configured policy, detailed examination of the packet, or both. Detailed examination of the packet is expected to happen closer to the edge of the network so that the core switches and routers are not overloaded.

Switches and routers along the path can use the class information to limit the amount of resources allocated per traffic class. The behavior of an individual device when handling traffic in the DiffServ architecture is called per-hop behavior. If all devices along a path have a consistent per-hop behavior, you can construct an end-to-end QoS solution.

Implementing QoS in your network can be a simple or complex task and depends on the QoS features offered by your internetworking devices, the traffic types and patterns in your network, and the granularity of control that you need over incoming and outgoing traffic.

Basic QoS Model

Figure 27-2 shows the basic QoS model. Actions at the ingress interface include classifying traffic, policing, and marking:

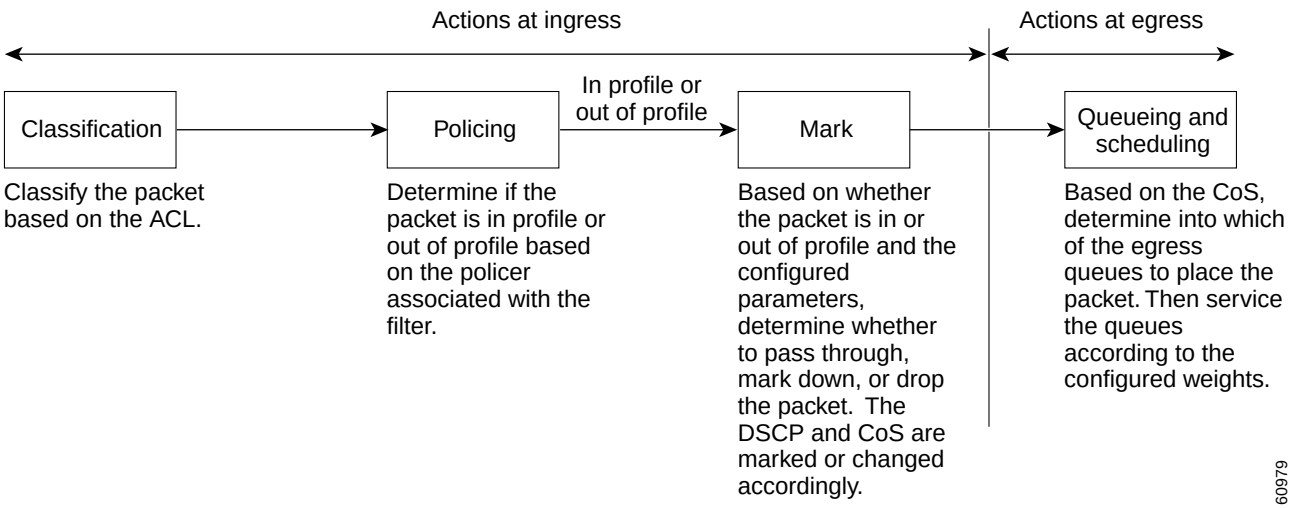
Note If you have the SI installed on your switch, only the queueing and scheduling features are available.

- Classifying distinguishes one kind of traffic from another. For more information, see the "Classification" section on page 27-5.
- Policing determines whether a packet is in or out of profile according to the configured policer, and the policer limits the bandwidth consumed by a flow of traffic. The result of this determination is passed to the marker. For more information, see the "Policing and Marking" section on page 27-7.
- Marking evaluates the policer and configuration information for the action to be taken when a packet is out of profile and decides what to do with the packet (pass through a packet without modification, mark down the DSCP value in the packet, or drop the packet). For more information, see the "Policing and Marking" section on page 27-7.

Actions at the egress interface include queueing and scheduling:

- Queueing evaluates the CoS value and determines which of the four egress queues in which to place the packet.
- Scheduling services the four egress queues based on their configured weighted round robin (WRR) weights.

Figure 27-2 Basic QoS Model


Actions at ingress
Actions at egress
Classification
Policing
In profile or out of profile
Mark
Queueing and scheduling
Classify the packet based on the ACL.
Determine if the packet is in profile or out of profile based on the policer associated with the filter.
Based on whether the packet is in or out of profile and the configured parameters, determine whether to pass through, mark down, or drop the packet. The DSCP and CoS are marked or changed accordingly.
Based on the CoS, determine into which of the egress queues to place the packet. Then service the queues according to the configured weights.
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Classification

Note This feature is available only if your switch is running the EI.

Classification is the process of distinguishing one kind of traffic from another by examining the fields in the packet.

Classification occurs only on a physical interface basis. No support exists for classifying packets at the VLAN level.

You specify which fields in the frame or packet that you want to use to classify incoming traffic.

For non-IP traffic, you have these classification options:

- Use the port default. If the frame does not contain a CoS value, the switch assigns the default port CoS value to the incoming frame.
- Trust the CoS value in the incoming frame (configure the port to trust CoS). Layer 2 802.1Q frame headers carry the CoS value in the three most-significant bits of the Tag Control Information field. CoS values range from 0 for low priority to 7 for high priority.

  The trust DSCP configuration is meaningless for non-IP traffic. If you configure a port with this option and non-IP traffic is received, the switch assigns the default port CoS value and classifies traffic based on the CoS value.

For IP traffic, you have these classification options:

- Trust the IP DSCP in the incoming packet (configure the port to trust DSCP). The switch assigns the same DSCP to the packet for internal use. The IETF defines the 6 most-significant bits of the 1-byte ToS field as the DSCP. The priority represented by a particular DSCP value is configurable. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.
- Trust the CoS value (if present) in the incoming packet. The switch generates the DSCP by using the CoS-to-DSCP map.

Note An interface can be configured to trust either CoS or DSCP, but not both at the same time.

Classification Based on QoS ACLs

You can use IP standard, IP extended, and Layer 2 MAC access control lists (ACLs) to define a group of packets with the same characteristics (*class*). In the QoS context, the permit and deny actions in the access control entries (ACEs) have different meanings than with security ACLs:

- If a match with a permit action is encountered (first-match principle), the specified QoS-related action is taken.
- If no match with a permit action is encountered and all the ACEs have been examined, no QoS processing occurs on the packet.
- If multiple ACLs are configured on an interface, the packet matches the first ACL with a permit action, and QoS processing begins.

- Configuration of a deny action is not supported in QoS ACLs on the switch.
- System-defined masks are allowed in class maps with these restrictions:
  - A combination of system-defined and user-defined masks cannot be used in the multiple class maps that are a part of a policy map.
  - System-defined masks that are a part of a policy map must all use the same type of system mask. For example, a policy map cannot have a class map that uses the **permit tcp any any** ACE and another that uses the **permit ip any any** ACE.
  - A policy map can contain multiple class maps that all use the same user-defined mask or the same system-defined mask.

Note For more information about system-defined masks, see the "Understanding Access Control Parameters" section on page 26-4.

For more information about ACL restrictions, see the "Configuring ACLs" section on page 26-6.

After a traffic class has been defined with the ACL, you can attach a policy to it. A policy might contain multiple classes with actions specified for each one of them. A policy might include commands to classify the class as a particular aggregate (for example, assign a DSCP) or rate-limit the class. This policy is then attached to a particular port on which it becomes effective.

You implement IP ACLs to classify IP traffic by using the **access-list** global configuration command; you implement Layer 2 MAC ACLs to classify Layer 2 traffic by using the **mac access-list extended** global configuration command.

Classification Based on Class Maps and Policy Maps

A class map is a mechanism that you use to isolate and name a specific traffic flow (or class) from all other traffic. The class map defines the criteria used to match against a specific traffic flow to further classify it; the criteria can include matching the access group defined by the ACL. If you have more than one type of traffic that you want to classify, you can create another class map and use a different name. After a packet is matched against the class-map criteria, you further classify it through the use of a policy map.

A policy map specifies which traffic class to act on. Actions can include setting a specific DSCP value in the traffic class or specifying the traffic bandwidth limitations and the action to take when the traffic is out of profile. Before a policy map can be effective, you must attach it to an interface.

You create a class map by using the **class-map** global configuration command or the **class** policy-map configuration command. You should use the **class-map** global configuration command when the map is shared among many ports. When you enter the **class-map** global configuration command, the switch enters the class-map configuration mode. In this mode, you define the match criterion for the traffic by using the **match** class-map configuration command.

You create and name a policy map by using the **policy-map** global configuration command. When you enter this command, the switch enters the policy-map configuration mode. In this mode, you specify the actions to take on a specific traffic class by using the **class** policy-map configuration or **set** policy-map class configuration command. To make the policy map effective, you attach it to an interface by using the **service-policy** interface configuration command.

The policy map can also contain commands that define the policer, the bandwidth limitations of the traffic, and the action to take if the limits are exceeded. For more information, see the "Policing and Marking" section on page 27-7.

A policy map also has these characteristics:

- A policy map can contain multiple class statements.
- A separate policy-map class can exist for each type of traffic received through an interface.
- A policy-map configuration state supersedes any actions due to an interface trust state.

For configuration information, see the "Configuring a QoS Policy" section on page 27-23.

Policing and Marking

Note This feature is available only if your switch is running the EI.

Policing involves creating a policer that specifies the bandwidth limits for the traffic. Packets that exceed the limits are *out of profile* or *nonconforming*. Each policer specifies the action to take for packets that are in or out of profile. These actions, carried out by the marker, include dropping the packet or marking down the packet with a new user-defined value.

You can create an individual policer. QoS applies the bandwidth limits specified in the policer separately to each matched traffic class. You configure this type of policer within a policy map by using the **policy-map** configuration command.

When configuring policing and policers, keep these items in mind:

- By default, no policers are configured.
- Policers can only be configured on a physical port. There is no support for policing at a VLAN level.
- Only one policer can be applied to a packet in the input direction.
- Only the average rate and committed burst parameters are configurable.
- Policing occurs on the ingress interfaces:
  - 60 policers are supported on ingress Gigabit-capable Ethernet ports.
  - 6 policers are supported on ingress 10/100 Ethernet ports.
  - Granularity for the average burst rate is 1 Mbps for 10/100 ports and 8 Mbps for Gigabit Ethernet ports.
- On an interface configured for QoS, all traffic received through the interface is classified, policed, and marked according to the policy map attached to the interface. On a trunk interface configured for QoS, traffic in *all* VLANs received through the interface is classified, policed, and marked according to the policy map attached to the interface.

Note You cannot configure policers on the egress interfaces.

Mapping Tables

Note This feature is available only if your switch is running the EI.

During classification, QoS uses a configurable CoS-to-DSCP map to derive an internal DSCP value from the received CoS value. This DSCP value represents the priority of the traffic.

Before the traffic reaches the scheduling stage, QoS uses the configurable DSCP-to-CoS map to derive a CoS value from the internal DSCP value. The CoS value is used to select one of the four egress queues.

The CoS-to-DSCP and DSCP-to-CoS maps have default values that might or might not be appropriate for your network.

For configuration information, see the "Configuring CoS Maps" section on page 27-31.

Queueing and Scheduling

Note Both the SI and EI support this feature.

The switch gives QoS-based 802.1P CoS values. QoS uses classification and scheduling to send network traffic from the switch in a predictable manner. QoS classifies frames by assigning priority-indexed CoS values to them and gives preference to higher-priority traffic such as telephone calls.

How Class of Service Works

Before you set up 802.1P CoS on a Catalyst 2950 or Catalyst 2955 switch that operates with the Catalyst 6000 family of switches, refer to the Catalyst 6000 documentation. There are differences in the 802.1P implementation that you should understand to ensure compatibility.

Port Priority

Frames received from users in the administratively-defined VLANs are classified or *tagged* for transmission to other devices. Based on rules that you define, a unique identifier (the tag) is inserted in each frame header before it is forwarded. The tag is examined and understood by each device before any broadcasts or transmissions to other switches, routers, or end stations. When the frame reaches the last switch or router, the tag is removed before the frame is sent to the target end station. VLANs that are assigned on trunk or access ports without identification or a tag are called *native* or *untagged* frames.

For IEEE 802.1Q frames with tag information, the priority value from the header frame is used. For native frames, the default priority of the input port is used.

Port Scheduling

Each port on the switch has a single receive queue buffer (the *ingress* port) for incoming traffic. When an untagged frame arrives, it is assigned the value of the port as its port default priority. You assign this value by using the CLI or CMS. A tagged frame continues to use its assigned CoS value when it passes through the ingress port.

CoS configures each transmit port (the *egress* port) with a normal-priority transmit queue and a high-priority transmit queue, depending on the frame tag or the port information. Frames in the normal-priority queue are forwarded only after frames in the high-priority queue are forwarded.

The switch (802.1P user priority) has four priority queues. The frames are forwarded to appropriate queues based on the priority-to-queue mapping that you defined.

Egress CoS Queues

The switch supports four CoS queues for each egress port. For each queue, you can specify these types of scheduling:

- Strict priority scheduling

  Strict priority scheduling is based on the priority of queues. Packets in the high-priority queue always transmit first, and packets in the low-priority queue do not transmit until all the high-priority queues become empty.

  The default scheduling method is strict priority.

- Weighted round-robin (WRR) scheduling

  WRR scheduling requires you to specify a number that indicates the importance (weight) of the queue relative to the other CoS queues. WRR scheduling prevents the low-priority queues from being completely neglected during periods of high-priority traffic. The WRR scheduler transmits some packets from each queue in turn. The number of packets it sends corresponds to the relative importance of the queue. For example, if one queue has a weight of 3 and another has a weight of 4, three packets are sent from the first queue for every four that are sent from the second queue. By using this scheduling, low-priority queues have the opportunity to send packets even though the high-priority queues are not empty.

- Strict priority and WRR scheduling

  Strict priority and WRR scheduling, also referred to as strict priority queueing, uses one of the egress queues as an expedite queue (queue 4). The remaining queues participate in WRR. When the expedite queue is configured, it is a priority queue and is serviced until it is empty before the other queues are serviced by WRR scheduling.

  You can enable the egress expedite queue and assign WRR weights to the other queues by using the **wrr-queue bandwidth** *weight1 weight2 weight3* **0** global configuration commmand.

Configuring Auto-QoS

Note This feature is available only if your switch is running the EI.

You can use the auto-QoS feature to simplify the deployment of existing QoS features. Auto-QoS makes assumptions about the network design, and as a result, the switch can prioritize different traffic flows and appropriately use the egress queues instead of using the default QoS behavior (the switch offers best-effort service to each packet regardless of the packet contents or size and sends it from a single queue).

When you enable auto-QoS, it automatically classifies traffic based on the traffic type and ingress packet label. The switch uses the resulting classification to choose the appropriate egress queue.

You use auto-QoS commands to identify ports connected to Cisco IP Phones and to identify ports that receive trusted voice over IP (VoIP) traffic through an uplink. Auto-QoS then performs these functions:

- Detects the presence or absence of IP phones
- Configures QoS classification
- Configures egress queues

These sections describe how to configure auto-QoS on your switch:

- Generated Auto-QoS Configuration, page 27-10
- Effects of Auto-QoS on the Configuration, page 27-12
- Configuration Guidelines, page 27-12
- Enabling Auto-QoS for VoIP, page 27-12

Generated Auto-QoS Configuration

When auto-QoS is enabled, it uses the ingress packet label to classify traffic and to configure the egress queues as described in Table 27-2.

Table 27-2 Traffic Types, Ingress Packet Labels, Assigned Packet Labels, and Egress Queues

	VoIP Data Traffic Only From Cisco IP Phones	VoIP Control Traffic Only From Cisco IP Phones	Routing Protocol Traffic	STP BPDU[1] Traffic	All Other Traffic
Ingress DSCP	46	26	–	–	–
Ingress CoS	5	3	6	7	–
Assigned DSCP	46	26	48	56	0
Assigned CoS	5	3	6	7	0
CoS-to-Queue Map	5	3, 6, 7			0, 1, 2, 4
Egress Queue	Expedite queue	80% WRR			20% WRR

1. BPDU = bridge protocol data unit

Table 27-3 lists the generated auto-QoS configuration for the egress queues.

Table 27-3 Auto-QoS Configuration for the Egress Queues

Egress Queue	Queue Number	CoS-to-Queue Map	Queue Weight
Expedite	4	5	–
80% WRR	3	3, 6, 7	80%
20% WRR	1	0, 1, 2, 4	20%

When you enable the auto-QoS feature on the first interface, these automatic actions occur:

- When you enter the **auto qos voip trust** interface configuration command, the ingress classification on the interface is set to trust the QoS label received in the packet, and the egress queues on the interface are reconfigured (see Table 27-3).
- When you enter the **auto qos voip cisco-phone** interface configuration command, the trusted boundary feature is enabled. It uses the Cisco Discovery Protocol (CDP) to detect the presence or absence of a Cisco IP Phone. When a Cisco IP Phone is detected, the ingress classification on the interface is set to trust the QoS label received in the packet. When a Cisco IP Phone is absent, the ingress classification is set to not trust the QoS label in the packet. The egress queues on the interface are reconfigured (see Table 27-3).

  For information about the trusted boundary feature, see the "Configuring Trusted Boundary" section on page 27-20.

When you enable auto-QoS by using the **auto qos voip cisco-phone** or the **auto qos voip trust** interface configuration command, the switch automatically generates a QoS configuration based on the traffic type and ingress packet label and applies the commands listed in Table 27-4 to the interface.

Table 27-4 Generated Auto-QoS Configuration Command Equivalents

Description	Automatically Generated QoS Command Equivalent
The switch automatically enables standard QoS and configures the CoS-to-DSCP map (maps CoS values in incoming packets to a DSCP value) as shown in Table 27-2 on page 27-10.	`Switch(config)# mls qos map cos-dscp 0 8 16 26 32 46 48 56`
The switch automatically sets the ingress classification on the interface to trust the CoS value received in the packet.	`Switch(config-if)# mls qos trust cos`
If you entered the **auto qos voip cisco-phone** command, the switch automatically enables the trusted boundary feature, which uses the CDP to detect the presence or absence of a Cisco IP Phone.	`Switch(config-if)# mls qos trust device cisco-phone`

The switch automatically assigns egress queue usage (as shown in Table 27-3 on page 27-10) on this interface.
 	
The switch enables the egress expedite queue and assigns WRR weights to queues 1 and 3. (The lowest value for a WRR queue is 1. When the WRR weight of a queue is set to 0, this queue becomes an expedite queue.)
 	
The switch configures the CoS-to-egress-queue map:
• CoS values 0, 1, 2, and 4 select queue 1.
• CoS values 3, 6, and 7 select queue 3.
• CoS value 5 selects queue 4 (expedite queue).
 	
Because the expedite queue (queue 4) contains the VoIP data traffic, the queue is serviced until empty.
	`Switch(config)# wrr-queue bandwidth 20 1 80 0`
	`Switch(config)# wrr-queue cos-map 1 0 1 2 4`
	`Switch(config)# wrr-queue cos-map 3 3 6 7`
	`Switch(config)# wrr-queue cos-map 4 5`

Effects of Auto-QoS on the Configuration

When auto-QoS is enabled, the **auto qos voip** interface configuration command and the generated configuration are added to the running configuration.

Configuration Guidelines

Before configuring auto-QoS, you should be aware of this information:

- In this release, auto-QoS configures the switch only for VoIP with Cisco IP Phones.
- To take advantage of the auto-QoS defaults, do not configure any standard QoS commands before entering the auto-QoS commands. If necessary, you can fine-tune the QoS configuration, but we recommend that you do so only after the auto-QoS configuration is completed.
- You can enable auto-QoS on static, dynamic-access, voice VLAN access, and trunk ports.
- By default, the CDP is enabled on all interfaces. For auto-QoS to function properly, do not disable the CDP.
- Policing is not enabled in auto-QoS. You can manually enable policing, as described in the "Configuring a QoS Policy" section on page 27-23.

Enabling Auto-QoS for VoIP

Beginning in privileged EXEC mode, follow these steps to enable auto-QoS for VoIP within a QoS domain:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface that is connected to a Cisco IP Phone. You also can specify the uplink interface that is connected to another switch or router in the interior of the network.
Step 3	**auto qos voip** {**cisco-phone** | **trust**}	Enable auto-QoS. The keywords have these meanings: • **cisco-phone**—If the interface is connected to a Cisco IP Phone, the QoS labels of incoming packets are trusted only when the IP phone is detected. • **trust—**The uplink interface is connected to a trusted switch or router, and the VoIP classification in the ingress packet is trusted.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show auto qos interface** *interface-id*	Verify your entries. This command displays the auto-QoS configuration that was initially applied; it does not display any user changes to the configuration that might be in effect.

To display the QoS commands that are automatically generated when auto-QoS is enabled or disabled, enter the **debug autoqos** privileged EXEC command before enabling auto-QoS. For more information, see the "Using the debug autoqos Command" section on page 29-16.

To disable auto-QoS on an interface, use the **no auto qos voip** interface configuration command. When you enter this command, the switch changes the auto-QoS settings to the standard-QoS default settings for that interface.

To disable auto-QoS on the switch, use the **no auto qos voip** interface configuration command on all interfaces on which auto-QoS is enabled. When you enter this command on the last interface on which auto-QoS is enabled, the switch enables pass-through mode.

This example shows how to enable auto-QoS and to trust the QoS labels in incoming packets when the device connected to Fast Ethernet interface 0/1 is detected as a Cisco IP Phone:

```
Switch(config)# interface fastethernet0/1
Switch(config-if)# auto qos voip cisco-phone
```

This example shows how to enable auto-QoS and to trust the QoS labels in incoming packets when the switch or router connected to Gigabit Ethernet interface 0/1 is a trusted device:

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# auto qos voip trust
```

Displaying Auto-QoS Information

To display the inital auto-QoS configuration, use the **show auto qos** [**interface** [*interface-id*]] privileged EXEC command. To display any user changes to that configuration, use the **show running-config** privileged EXEC command. You can compare the **show auto qos** and the **show running-config** command output to identify the user-defined QoS settings.

To display information about the QoS configuration that might be affected by auto-QoS, use one of these commands:

- **show mls qos**
- **show mls qos map cos-dscp**
- **show wrr-queue bandwidth**
- **show wrr-queue cos-map**

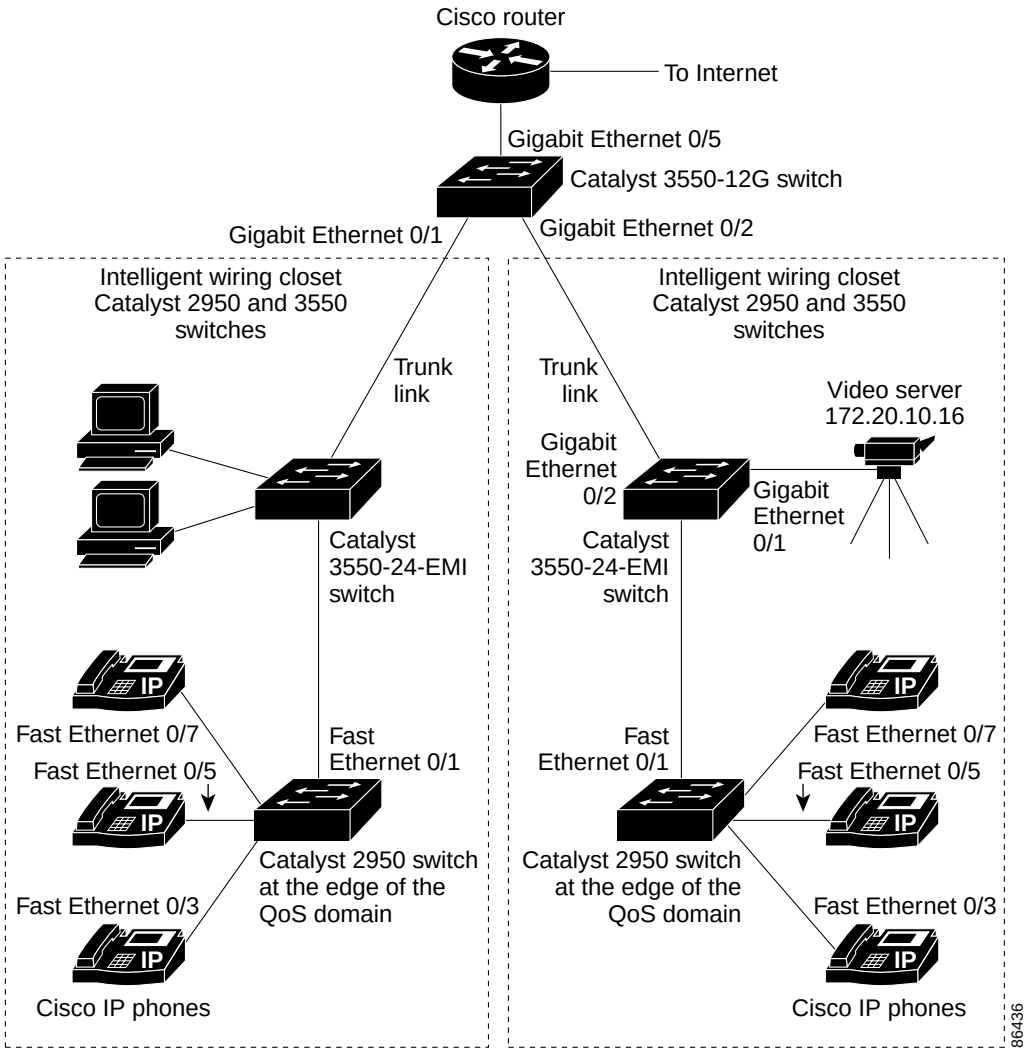
For more information about these commands, refer to the command reference for this release.

Auto-QoS Configuration Example

Note This example is applicable only if your switch is running the EI.

This section describes how you could implement auto-QoS in a network, as shown in Figure 27-3.

Figure 27-3 Auto-QoS Configuration Example Network



The intelligent wiring closets in Figure 27-3 are composed of Catalyst 2950 switches running the EI and Catalyst 3550 switches. The object of this example is to prioritize the VoIP traffic over all other traffic. To do so, enable auto-QoS on the switches at the edge of the QoS domains in the wiring closets.

Note You should not configure any standard-QoS commands before entering the auto-QoS commands. You can fine-tune the QoS configuration, but we recommend that you do so only after the auto-QoS configuration is completed.

Beginning in privileged EXEC mode, follow these steps to configure the switch at the edge of the QoS domain to prioritize the VoIP traffic over all other traffic:

	Command	Purpose
Step 1	**debug autoqos**	Enable debugging for auto-QoS. When debugging is enabled, the switch displays the QoS configuration that is automatically generated when auto-QoS is enabled.
Step 2	**configure terminal**	Enter global configuration mode.
Step 3	**cdp enable**	Enable CDP globally. By default, it is enabled.
Step 4	**interface fastethernet0/3**	Enter interface configuration mode.
Step 5	**auto qos voip cisco-phone**	Enable auto-QoS on the interface, and specify that the interface is connected to a Cisco IP Phone. The QoS labels of incoming packets are trusted only when the IP phone is detected.
Step 6	**interface fastethernet0/5**	Enter interface configuration mode.
Step 7	**auto qos voip cisco-phone**	Enable auto-QoS on the interface, and specify that the interface is connected to a Cisco IP Phone.
Step 8	**interface fastethernet0/7**	Enter interface configuration mode.
Step 9	**auto qos voip cisco-phone**	Enable auto-QoS on the interface, and specify that the interface is connected to a Cisco IP Phone.
Step 10	**interface fastethernet0/1**	Enter interface configuration mode.
Step 11	**auto qos voip trust**	Enable auto-QoS on the interface, and specify that the interface is connected to a trusted router or switch.
Step 12	**end**	Return to privileged EXEC mode.
Step 13	**show auto qos**	Verify your entries. This command displays the auto-QoS configuration that is initially applied; it does not display any user changes to the configuration that might be in effect. For information about the QoS configuration that might be affected by auto-QoS, see the “Displaying Auto-QoS Information” section on page 26-12.
Step 14	**copy running-config startup-config**	Save the **auto qos voip** interface configuration commands and the generated auto-QoS configuration in the configuration file.

Configuring Standard QoS

Before configuring standard QoS, you must have a thorough understanding of these items:

- The types of applications used and the traffic patterns on your network.
- Traffic characteristics and needs of your network. Is the traffic bursty? Do you need to reserve bandwidth for voice and video streams?
- Bandwidth requirements and speed of the network.
- Location of congestion points in the network.

This section describes how to configure standard QoS on your switch:

Note If your switch is running the SI, you can configure only the features described in the "Configuring Classification Using Port Trust States" and the "Configuring the Egress Queues" sections. You can also display the QoS information as described in the "Displaying Standard QoS Information" section.

- Default Standard QoS Configuration, page 27-16
- Configuration Guidelines, page 27-17
- Configuring Classification Using Port Trust States, page 27-17
- Configuring a QoS Policy, page 27-23
- Configuring CoS Maps, page 27-31
- Configuring the Egress Queues, page 27-34

Default Standard QoS Configuration

This is the default standard QoS configuration:

Note You can configure policy maps, policers, the CoS-to-DSCP map, and the DSCP-to-CoS map only if your switch is running the EI.

- The default port CoS value is 0.
- The CoS value of 0 is assigned to all incoming packets.
- The default port trust state is untrusted.
- No policy maps are configured.
- No policers are configured.
- The default CoS-to-DSCP map is shown in Table 27-6.
- The default DSCP-to-CoS map is shown in Table 27-7.
- The default scheduling method for the egress queues is strict priority.
- For default CoS and WRR values, see the "Configuring the Egress Queues" section on page 27-34.

Note In software releases earlier than Release 12.1(11)EA1, the switch uses the CoS value of incoming packets without modifying the DSCP value. You can configure this by enabling pass-through mode on the port. For more information, see the "Enabling Pass-Through Mode" section on page 27-22.

Configuration Guidelines

Note These guidelines are applicable only if your switch is running the EI.

Before beginning the QoS configuration, you should be aware of this information:

- You must disable the IEEE 802.3X flowcontrol on all ports before enabling QoS on the switch. To disable it, use the **flowcontrol receive off** and **flowcontrol send off** interface configuration commands.
- If you have EtherChannel ports configured on your switch, you must configure QoS classification, policing, mapping, and queueing on the individual physical ports that comprise the EtherChannel. You must decide whether the QoS configuration should match on all ports in the EtherChannel.
- It is not possible to match IP fragments against configured IP extended ACLs to enforce QoS. IP fragments are sent as best-effort traffic. IP fragments are denoted by fields in the IP header.
- All ingress QoS processing actions apply to control traffic (such as spanning-tree bridge protocol data units [BPDUs] and routing update packets) that the switch receives.
- Only an ACL that is created for physical interfaces can be attached to a class map.
- Only one ACL per class map and only one **match** command per class map are supported. The ACL can have multiple access control entries, which are commands that match fields against the contents of the packet.
- Policy maps with ACL classification in the egress direction are not supported and cannot be attached to an interface by using the **service-policy input** *policy-map-name* interface configuration command.
- In a policy map, the class named *class-default* is not supported. The switch does not filter traffic based on the policy map defined by the **class class-default** policy-map configuration command.
- For more information about guidelines for configuring ACLs, see the "Classification Based on QoS ACLs" section on page 27-5.
- For information about applying ACLs to physical interfaces, see the "Guidelines for Applying ACLs to Physical Interfaces" section on page 26-6.

Configuring Classification Using Port Trust States

This section describes how to classify incoming traffic by using port trust states:

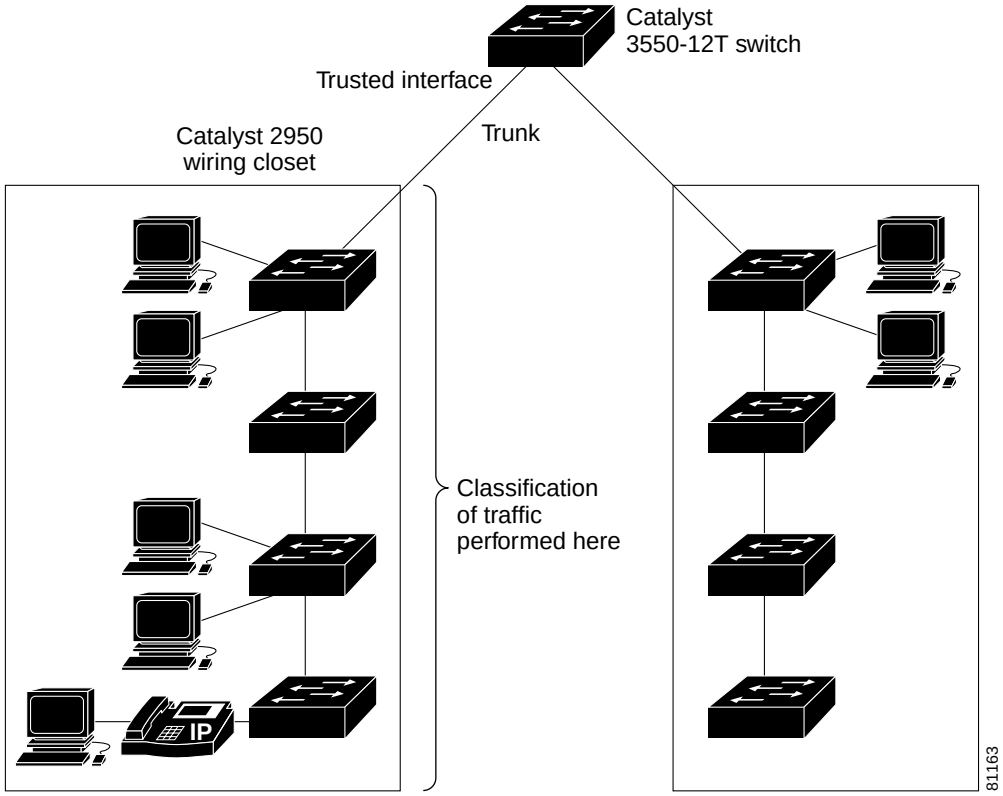
- Configuring the Trust State on Ports within the QoS Domain, page 27-18
- Configuring the CoS Value for an Interface, page 27-20
- Configuring Trusted Boundary, page 27-20
- Enabling Pass-Through Mode, page 27-22

Note Both the SI and EI support this feature.

Configuring the Trust State on Ports within the QoS Domain

Packets entering a QoS domain are classified at the edge of the QoS domain. When the packets are classified at the edge, the switch port within the QoS domain can be configured to one of the trusted states because there is no need to classify the packets at every switch within the QoS domain. Figure 27-4 shows a sample network topology.

Figure 27-4 Port Trusted States within the QoS Domain



Beginning in privileged EXEC mode, follow these steps to configure the port to trust the classification of the traffic that it receives:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to be trusted. Valid interfaces include physical interfaces.
Step 3	**mls qos trust** [**cos** | **dscp**]	Configure the port trust state. By default, the port is not trusted. The keywords have these meanings: **cos**—Classifies ingress packets with the packet CoS values. For tagged IP packets, the DSCP value of the packet is modified based on the CoS-to-DSCP map. The egress queue assigned to the packet is based on the packet CoS value. **dscp**—Classifies ingress packets with packet DSCP values. For non-IP packets, the packet CoS value is set to 0 for tagged packets; the default port CoS is used for untagged packets. Internally, the switch modifies the CoS value by using the DSCP-to-CoS map. This keyword is available only if your switch is running the EI. **Note** In software releases earlier than Release 12.1(11)EA1, the **mls qos trust** command is available only when the switch is running the EI. Use the **cos** keyword if your network is composed of Ethernet LANs. Use the **dscp** keyword if your network is not composed of only Ethernet LANs and if you are familiar with sophisticated QoS features and implementations. For more information about this command, refer to the command reference for this release.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show mls qos interface** [*interface-id*] [**policers**]	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return a port to its untrusted state, use the **no mls qos trust** interface configuration command.

For information on how to change the default CoS value, see the "Configuring the CoS Value for an Interface" section on page 27-20. For information on how to configure the CoS-to-DSCP map, see the "Configuring the CoS-to-DSCP Map" section on page 27-32.

Configuring the CoS Value for an Interface

QoS assigns the CoS value specified with the **mls qos cos** interface configuration command to untagged frames received on trusted and untrusted ports.

Beginning in privileged EXEC mode, follow these steps to define the default CoS value of a port or to assign the default CoS to all incoming packets on the port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to be trusted. Valid interfaces include physical interfaces.
Step 3	**mls qos cos** {*default-cos* | **override**}	Configure the default CoS value for the port. • For *default-cos*, specify a default CoS value to be assigned to a port. If the port is CoS trusted and packets are untagged, the default CoS value becomes the CoS value for the packet. The CoS range is 0 to 7. The default is 0. • Use the **override** keyword to override the previously configured trust state of the incoming packets and to apply the default port CoS value to all incoming packets. By default, CoS override is disabled. Use the **override** keyword when all incoming packets on certain ports deserve higher priority than packets entering from other ports. Even if a port was previously set to trust DSCP, this command overrides the previously configured trust state, and all the incoming CoS values are assigned the default CoS value configured with this command. If an incoming packet is tagged, the CoS value of the packet is modified with the default CoS of the port at the egress port.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show mls qos interface**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default setting, use the **no mls qos cos** {*default-cos* | **override**} interface configuration command.

Configuring Trusted Boundary

In a typical network, you connect a Cisco IP Phone to a switch port as shown in Figure 27-4 on page 27-18. Traffic sent from the telephone to the switch is typically marked with a tag that uses the 802.1Q header. The header contains the VLAN information and the CoS 3-bit field, which determines the priority of the packet. For most Cisco IP Phone configurations, the traffic sent from the telephone to the switch is trusted to ensure that voice traffic is properly prioritized over other types of traffic in the network. By using the **mls qos trust cos** interface configuration command, you can configure the switch port to which the telephone is connected to trust the CoS labels of all traffic received on that port.

In some situations, you also might connect a PC or workstation to the IP phone. In these cases, you can use the **switchport priority extend cos** interface configuration command to configure the telephone through the switch CLI to override the priority of the traffic received from the PC. With this command, you can prevent a PC from taking advantage of a high-priority data queue.

However, if a user bypasses the telephone and connects the PC directly to the switch, the CoS labels generated by the PC are trusted by the switch (because of the trusted CoS setting) and can allow misuse of high-priority queues. The trusted boundary feature solves this problem by using the CDP to detect the presence of a Cisco IP Phone (such as the Cisco IP Phone 7910, 7935, 7940, and 7960) on a switch port. If the telephone is not detected, the trusted boundary feature disables the trusted setting on the switch port and prevents misuse of a high-priority queue.

Beginning in privileged EXEC mode, follow these steps to configure trusted boundary on a switch port:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**cdp enable**	Enable CDP globally. By default, it is enabled.
Step 3	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to be trusted. Valid interfaces include physical interfaces.
Step 4	**cdp enable**	Enable CDP on the interface. By default, CDP is enabled.
Step 5	**mls qos trust device cisco-phone**	Configure the Cisco IP Phone as a trusted device on the interface. You cannot enable both trusted boundary and auto-QoS (**auto qos voip** interface configuration command) at the same time; they are mutually exclusive.
Step 6	**mls qos trust cos**	Configure the port trust state to trust the CoS value of the ingress packet. By default, the port is not trusted. **Note** In software releases earlier than Release 12.1(11)EA1, the **mls qos trust cos** command is available only when the switch is running the EI. For more information on this command, refer to the command reference for this release.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show mls qos interface** [*interface-id*] [**policers**]	Verify your entries.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

When you enter the **no mls qos trust** interface configuration command, trusted boundary is not disabled. If this command is entered and the port is connected to a Cisco IP Phone, the port does not trust the classification of traffic that it receives. To disable trusted boundary, use the **no mls qos trust device** interface configuration command

If you enter the **mls qos cos override** interface configuration command, the port does not trust the classification of the traffic that it receives, even when it is connected to a Cisco IP Phone.

You cannot enable trusted boundary if auto-QoS is already enabled and vice-versa. If auto-QoS is enabled and a Cisco IP Phone is absent on a port, the port does not trust the classification of traffic that it receives.

Table 27-5 lists the port configuration when an IP phone is present or absent.

Table 27-5 Port Configurations When Trusted Boundary is Enabled

Port Configuration	When a Cisco IP Phone is Present	When a Cisco IP Phone is Absent
The port trusts the CoS value of the incoming packet.	The packet CoS value is trusted.	The packet CoS value is assigned the default CoS value.
The port trusts the DSCP value of the incoming packet.	The packet DSCP value is trusted.	For tagged non-IP packets, the packet CoS value is set to 0. For untagged non-IP packets, the packet CoS value is assigned the default CoS value.
The port assigns the default CoS value to incoming packets.	The packet CoS value is assigned the default CoS value.	The packet CoS value is assigned the default CoS value.

Enabling Pass-Through Mode

In software releases earlier than Release 12.1(11)EA1, the switch is in pass-through mode. It uses the CoS value of incoming packets without modifying the DSCP value and sends the packets from one of the four egress queues. You cannot enable or disable pass-through mode if your switch is running a software release earlier than Release 12.1(11)EA1.

In Release 12.1(11)EA1 or later, the switch assigns a CoS value of 0 to all incoming packets without modifying the packets. The switch offers best-effort service to each packet regardless of the packet contents or size and sends it from a single egress queue.

Beginning in privileged EXEC mode, follow these steps to enable pass-through mode:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface on which pass-through mode is enabled. Valid interfaces include physical interfaces.
Step 3	**mls qos trust cos pass-through dscp**	Enable pass-through mode. The interface is configured to trust the CoS value of the incoming packets and to send them without modifying the DSCP value.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show mls qos interface** [*interface-id*]	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable pass-through mode, use the **no mls qos trust pass-through dscp** interface configuration command.

If you enter the **mls qos cos override** and the **mls qos trust** [**cos** | **dscp**] interface commands when pass-through mode is enabled, pass-through mode is disabled.

If you enter the **mls qos trust cos pass-through dscp** interface configuration command when the **mls qos cos override** and the **mls qos trust** [**cos** | **dscp**] interface commands are already configured, pass-through mode is disabled.

Configuring a QoS Policy

Note This feature is available only if your switch is running the EI.

Configuring a QoS policy typically requires classifying traffic into classes, configuring policies applied to those traffic classes, and attaching policies to interfaces.

For background information, see the "Classification" section on page 27-5 and the "Policing and Marking" section on page 27-7.

This section contains this configuration information:

- Classifying Traffic by Using ACLs, page 27-24
- Classifying Traffic by Using Class Maps, page 27-27
- Classifying, Policing, and Marking Traffic by Using Policy Maps, page 27-28

Classifying Traffic by Using ACLs

You can classify IP traffic by using IP standard or IP extended ACLs; you can classify Layer 2 traffic by using Layer 2 MAC ACLs.

Beginning in privileged EXEC mode, follow these steps to create an IP standard ACL for IP traffic:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list** *access-list-number* {**permit** | **remark**} {*source source-wildcard* | **host** *source* | **any**}	Create an IP standard ACL, repeating the command as many times as necessary. For *access-list-number*, enter the ACL number. The range is 1 to 99 and 1300 to 1999. Enter **permit** to specify whether to permit access if conditions are matched. Enter **remark** to specify an ACL entry comment up to 100 characters. **Note** Deny statements are not supported for QoS ACLs. See the "Classification Based on QoS ACLs" section on page 27-5 for more details. The *source* is the source address of the network or host from which the packet is being sent, specified in one of three ways: • The 32-bit quantity in dotted decimal format. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. You do not need to enter a source wildcard. • The keyword **host** as an abbreviation for *source* and *source-wildcard* of *source* 0.0.0.0. (Optional) The *source-wildcard* variable applies wildcard bits to the source (see first bullet item).
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show access-lists**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

For more information about creating IP standard ACLs, see the "Guidelines for Applying ACLs to Physical Interfaces" section on page 26-6.

To delete an ACL, use the **no access-list** *access-list-number* global configuration command.

This example shows how to allow access for only those hosts on the two specified networks. The wildcard bits apply to the host portions of the network addresses. Any host with a source address that does not match the ACL statements is rejected.

```
Switch(config)# access-list 1 permit 192.5.255.0 0.0.0.255
Switch(config)# access-list 1 permit 36.0.0.0 0.0.0.255
```

Beginning in privileged EXEC mode, follow these steps to create an IP extended ACL for IP traffic:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list** *access-list-number* {**permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} **[operator** *port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] [**dscp** *dscp-value*] [**time-range** *time-range-name*]	Create an IP extended ACL, repeating the command as many times as necessary. For *access-list-number*, enter the ACL number. The range is 100 to 199 and 2000 to 2699. Enter **permit** to permit access if conditions are matched. Enter **remark** to specify an ACL entry comment up to 100 characters. **Note** Deny statements are not supported for QoS ACLs. See the "Classification Based on QoS ACLs" section on page 27-5 for more details. For *protocol*, enter the name or number of an IP protocol. Use the question mark (**?**) to see a list of available protocol keywords. For *source*, enter the network or host from which the packet is being sent. For *source-wildcard*, enter the wildcard bits by placing ones in the bit positions that you want to ignore. You specify the *source* and *source-wilcard* by using dotted decimal notation, by using the **any** keyword as an abbreviation for *source* 0.0.0.0 *source-wildcard* 255.255.255.255, or by using the **host** keyword for *source* 0.0.0.0. For *destination*, enter the network or host to which the packet is being sent. You have the same options for specifying the *destination* and *destination-wildcard* as those described for *source* and *source-wildcard*. Define a destination or source port. • The *operator* can be only **eq** (equal). • If *operator* is after *source source-wildcard*, conditions match when the source port matches the defined port. • If *operator* is after *destination destination-wildcard*, conditions match when the destination port matches the defined port. • The *port* is a decimal number or name of a TCP or UDP port. The number can be from 0 to 65535. • Use TCP port names only for TCP traffic. • Use UDP port names only for UDP traffic. Enter **dscp** to match packets with any of the 13 supported DSCP values (0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56) or use the question mark (**?**) to see a list of available values. The **time-range** keyword is optional. For information about this keyword, see the "Applying Time Ranges to ACLs" section on page 26-15.
Step 3	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 4	**show access-lists**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

For more information about creating IP extended ACLs, see the "Guidelines for Applying ACLs to Physical Interfaces" section on page 26-6.

To delete an ACL, use the **no access-list** *access-list-number* global configuration command.

This example shows how to create an ACL that permits only TCP traffic from the destination IP address 128.88.1.2 with TCP port number 25:

```
Switch(config)# access-list 102 permit tcp 0.0.0.0 255.255.255.255 128.88.1.2 0.0.0.0 eq
25
```

Beginning in privileged EXEC mode, follow these steps to create a Layer 2 MAC ACL for Layer 2 traffic:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mac access-list extended** *name*	Create a Layer 2 MAC ACL by specifying the name of the list. After entering this command, the mode changes to extended MAC ACL configuration.
Step 3	**permit** {**any** | **host** *source MAC address*} {**any** | **host** *destination MAC address*} [**aarp** | **amber** | **appletalk** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** |**vines-ip** | **xns-idp**]	Enter **permit** to permit access if conditions are matched. **Note** Deny statements are not supported for QoS ACLs. See the "Classification Based on QoS ACLs" section on page 27-5 for more details. For *source MAC address*, enter the MAC address of the host from which the packet is being sent. You specify this by using the **any** keyword to deny any source MAC address or by using the **host** keyword and the source in the hexadecimal format (H.H.H). For *destination MAC address*, enter the MAC address of the host to which the packet is being sent. You specify this by using the **any** keyword to deny any destination MAC address or by using the **host** keyword and the destination in the hexadecimal format (H.H.H). (Optional) You can also enter these options: **aarp** | **amber** | **appletalk** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** |**vines-ip** | **xns-idp** (a non-IP protocol).
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show access-lists** [*number* | *name*]	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

For more information about creating MAC extended ACLs, see the "Creating Named MAC Extended ACLs" section on page 26-18.

To delete an ACL, use the **no mac access-list extended** *name* global configuration command.

This example shows how to create a Layer 2 MAC ACL with a permit statement. The statement allows traffic from the host with MAC address 0001.0000.0001 to the host with MAC address 0002.0000.0001.

```
Switch(config)# mac access-list extended maclist1
Switch(config-ext-macl)# permit host 0001.0000.0001 host 0002.0000.0001
```

Classifying Traffic by Using Class Maps

You use the **class-map** global configuration command to isolate a specific traffic flow (or class) from all other traffic and to name it. The class map defines the criteria to use to match against a specific traffic flow to further classify it. Match statements can only include ACLs. The match criterion is defined with one match statement entered within the class-map configuration mode.

Note You can also create class maps during policy map creation by using the **class** policy-map configuration command. For more information, see the "Classifying, Policing, and Marking Traffic by Using Policy Maps" section on page 27-28.

Beginning in privileged EXEC mode, follow these steps to create a class map and to define the match criterion to classify traffic:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list** *access-list-number* **permit** {*source source-wildcard* | **host** *source* | **any**} or **access-list** *access-list-number* {**permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any**} [*operator port*] [**dscp** *dscp-value*] [**time-range** *time-range-name*] or **mac access-list extended** *name* **permit** {**any** | **host** *source MAC address*} {**any** | **host** *destination MAC address*} [**aarp** | **amber** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** |**vines-ip** | **xns-idp**]	Create an IP standard or extended ACL for IP traffic or a Layer 2 MAC ACL for non-IP traffic, repeating the command as many times as necessary. For more information, see the "Guidelines for Applying ACLs to Physical Interfaces" section on page 26-6 and the "Classifying Traffic by Using ACLs" section on page 27-24. For more information on the **mac access-list extended** *name* command, see the "Creating Named MAC Extended ACLs" section on page 26-18. **Note** Deny statements are not supported for QoS ACLs. See the "Classification Based on QoS ACLs" section on page 27-5 for more details.
Step 3	**class-map** *class-map-name*	Create a class map, and enter class-map configuration mode. By default, no class maps are defined. For *class-map-name*, specify the name of the class map.

	Command	Purpose
Step 4	**match** {**access-group** *acl-index* | **access-group name** *acl-name* | **ip dscp** *dscp-list*}	Define the match criterion to classify traffic. By default, no match criterion is supported. Only one match criterion per class map is supported, and only one ACL per class map is supported. For **access-group** *acl-index* or **access-group name** *acl-name*, specify the number or name of the ACL created in Step 3. For **ip dscp** *dscp-list*, enter a list of up to eight IP DSCP values for each match statement to match against incoming packets. Separate each value with a space. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show class-map** [*class-map-name*]	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete an existing class map, use the **no class-map** *class-map-name* global configuration command. To remove a match criterion, use the **no match** {**access-group** *acl-index* | **name** *acl-name* | **ip dscp**} class-map configuration command.

This example shows how to configure the class map called *class1*. The *class1* has one match criterion, which is an ACL called *103*.

```
Switch(config)# access-list 103 permit any any tcp eq 80
Switch(config)# class-map class1
Switch(config-cmap)# match access-group 103
Switch(config-cmap)# end
Switch#
```

Classifying, Policing, and Marking Traffic by Using Policy Maps

A policy map specifies which traffic class to act on. Actions can include trusting the CoS or DSCP values in the traffic class; setting a specific DSCP value in the traffic class; and specifying the traffic bandwidth limitations for each matched traffic class (policer) and the action to take when the traffic is out of profile (marking).

A policy map also has these characteristics:

- A policy map can contain multiple class statements, each with different match criteria and policers.
- A separate policy-map class can exist for each type of traffic received through an interface.

You can attach only one policy map per interface in the input direction.

Beginning in privileged EXEC mode, follow these steps to create a policy map:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list** *access-list-number* **permit** {*source source-wildcard* | **host** *source* | **any**} or **access-list** *access-list-number* {**permit** | **remark**} *protocol* {*source source-wildcard* | **host** *source* | **any**} [*operator port*] {*destination destination-wildcard* | **host** *destination* | **any}** [*operator port] [dscp dscp-value*] [**time-range** *time-range-name*] or **mac access-list extended** *name* **permit** {**any** | **host** *source MAC address*} {**any** | **host** *destination MAC address*} [**aarp** | **amber** | **appletalk** |**dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** |**vines-ip** | **xns-idp**]	Create an IP standard or extended ACL for IP traffic or a Layer 2 MAC ACL for non-IP traffic, repeating the command as many times as necessary. For more information, see the "Classifying Traffic by Using ACLs" section on page 27-24. **Note** Deny statements are not supported for QoS ACLs. See the "Classification Based on QoS ACLs" section on page 27-5 for more details. For more information on the **mac access-list extended** *name* command, see the "Creating Named MAC Extended ACLs" section on page 26-18.
Step 3	**policy-map** *policy-map-name*	Create a policy map by entering the policy map name, and enter policy-map configuration mode. By default, no policy maps are defined. The default behavior of a policy map is to set the DSCP to 0 if the packet is an IP packet and to set the CoS to 0 if the packet is tagged. No policing is performed.
Step 4	**class** *class-map-name* [**access-group name** *acl-index-or-name*]	Define a traffic classification, and enter policy-map class configuration mode. By default, no policy map class maps are defined. If a traffic class has already been defined by using the **class-map** global configuration command, specify its name for *class-map-name* in this command. For **access-group name** *acl-index-or-name*, specify the number or name of the ACL created in Step 2. **Note** In a policy map, the class named *class-default* is not supported. The switch does not filter traffic based on the policy map defined by the **class class-default** policy-map configuration command.

	Command	Purpose
Step 5	**set** {**ip dscp** *new-dscp*}	Classify IP traffic by setting a new value in the packet. For **ip dscp** *new-dscp*, enter a new DSCP value to be assigned to the classified traffic. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.
Step 6	**police** *rate-bps burst-byte* [**exceed-action** {**drop** | **dscp** *dscp-value*}]	Define a policer for the classified traffic. You can configure up to 60 policers on ingress Gigabit-capable Ethernet ports and up to 6 policers on ingress 10/100 Ethernet ports. For *rate-bps*, specify average traffic rate in bits per second (bps). The range is 1 Mbps to 100 Mbps for 10/100 Ethernet ports and 8 Mbps to 1000 Mbps for the Gigabit-capable Ethernet ports. For *burst-byte*, specify the normal burst size in bytes. The values supported on the 10/100 ports are 4096, 8192, 16384, 32768, and 65536. The values supported on the Gigabit-capable Ethernet ports are 4096, 8192, 16348, 32768, 65536, 131072, 262144, and 524288. (Optional) Specify the action to take when the rates are exceeded. Use the **exceed-action drop** keywords to drop the packet. Use the **exceed-action dscp** *dscp-value* keywords to mark down the DSCP value and send the packet.
Step 7	**exit**	Return to policy-map configuration mode.
Step 8	**exit**	Return to global configuration mode.
Step 9	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to attach to the policy map. Valid interfaces include physical interfaces.
Step 10	**service-policy input** *policy-map-name*	Apply specified policy map to the input of a particular interface. Only one policy map per interface per direction is supported.
Step 11	**end**	Return to privileged EXEC mode.
Step 12	**show policy-map** [*policy-map-name* **class** *class-name*]	Verify your entries.
Step 13	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete an existing policy map, use the **no policy-map** *policy-map-name* global configuration command. To delete an existing class map, use the **no class** *class-map-name* policy-map configuration command. To remove an assigned DSCP value, use the **no set ip dscp** *new-dscp* policy-map configuration command. To remove an existing policer, use the **no police** *rate-bps burst-byte* [**exceed-action** {**drop** | **dscp** *dscp-value*}] policy-map configuration command. To remove the policy map and interface association, use the **no service-policy input** *policy-map-name* interface configuration command.

This example shows how to create a policy map and attach it to an ingress interface. In the configuration, the IP standard ACL permits traffic from network 10.1.0.0. For traffic matching this classification, the DSCP value in the incoming packet is trusted. If the matched traffic exceeds an average traffic rate of 5000000 bps and a normal burst size of 8192 bytes, its DSCP is marked down to a value of 10 and sent.

```
Switch(config)# access-list 1 permit 10.1.0.0 0.0.255.255
Switch(config)# class-map ipclass1
Switch(config-cmap)# match access-group 1
Switch(config-cmap)# exit
Switch(config)# policy-map flow1t
Switch(config-pmap)# class ipclass1
Switch(config-pmap-c)# police 5000000 8192 exceed-action dscp 10
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# switchport mode access
Switch(config-if)# service-policy input flow1t
```

This example shows how to create a Layer 2 MAC ACL with two permit statements and attach it to an ingress interface. The first permit statement allows traffic from the host with MAC address 0001.0000.0001 destined for the host with MAC address 0002.0000.0001.

```
Switch(config)# mac access-list extended maclist1
Switch(config-ext-mac)# permit host 0001.0000.0001 host 0002.0000.0001
Switch(config-ext-mac)# exit
Switch(config)# mac access-list extended maclist2
Switch(config-ext-mac)# permit host 0001.0000.0003 host 0002.0000.0003
Switch(config-ext-mac)# exit
Switch(config)# class-map macclass1
Switch(config-cmap)# match access-group name maclist1
Switch(config-cmap)# exit
Switch(config)# policy-map macpolicy1
Switch(config-pmap)# class macclass1
Switch(config-pmap-c)# set ip dscp 56
Switch(config-pmap-c)# exit
Switch(config-pmap)# class macclass2 maclist2
Switch(config-pmap-c)# set ip dscp 48
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# switchport mode trunk
Switch(config-if)# mls qos trust cos
Switch(config-if)# service-policy input macpolicy1
```

Configuring CoS Maps

Note This feature is available only if your switch is running the EI.

This section describes how to configure the CoS maps:

- Configuring the CoS-to-DSCP Map, page 27-32
- Configuring the DSCP-to-CoS Map, page 27-33

All the maps are globally defined.

Configuring the CoS-to-DSCP Map

You use the CoS-to-DSCP map to map CoS values in incoming packets to a DSCP value that QoS uses internally to represent the priority of the traffic.

Table 27-6 shows the default CoS-to-DSCP map.

Table 27-6 Default CoS-to-DSCP Map

CoS value	0	1	2	3	4	5	6	7
DSCP value	0	8	16	24	32	40	48	56

If these values are not appropriate for your network, you need to modify them.

Beginning in privileged EXEC mode, follow these steps to modify the CoS-to-DSCP map:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mls qos map cos-dscp** *dscp1...dscp8*	Modify the CoS-to-DSCP map. For *dscp1...dscp8*, enter 8 DSCP values that correspond to CoS values 0 to 7. Separate each DSCP value with a space. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show mls qos maps cos-dscp**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default map, use the **no mls qos map cos-dscp** global configuration command.

This example shows how to modify and display the CoS-to-DSCP map:

```
Switch# configure terminal
Switch(config)# mls qos map cos-dscp 8 8 8 8 24 32 56 56
Switch(config)# end
Switch# show mls qos maps cos-dscp

Cos-dscp map:
        cos:  0  1  2  3  4  5  6  7
     --------------------------------
       dscp:  8  8  8  8 24 32 56 56
```

Configuring the DSCP-to-CoS Map

You use the DSCP-to-CoS map to map DSCP values in incoming packets to a CoS value, which is used to select one of the four egress queues.

The switch supports these DSCP values: 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56.

Table 27-7 shows the default DSCP-to-CoS map.

Table 27-7 Default DSCP-to-CoS Map

DSCP values	0	8, 10	16, 18	24, 26	32, 34	40, 46	48	56
CoS values	0	1	2	3	4	5	6	7

If these values are not appropriate for your network, you need to modify them.

Beginning in privileged EXEC mode, follow these steps to modify the DSCP-to-CoS map:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**mls qos map dscp-cos** *dscp-list* **to** *cos*	Modify the DSCP-to-CoS map. For *dscp-list*, enter up to 13 DSCP values separated by spaces. Then enter the **to** keyword. For *cos*, enter the CoS value to which the DSCP values correspond. The supported DSCP values are 0, 8, 10, 16, 18, 24, 26, 32, 34, 40, 46, 48, and 56. The CoS range is 0 to 7.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show mls qos maps dscp-cos**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return to the default map, use the **no mls qos map dscp-cos** global configuration command.

This example shows how the DSCP values 26 and 48 are mapped to CoS value 7. For the remaining DSCP values, the DSCP-to-CoS mapping is the default.

```
Switch(config)# mls qos map dscp-cos 26 48 to 7
Switch(config)# exit

Switch# show mls qos maps dscp-cos

Dscp-cos map:
       dscp:  0  8 10 16 18 24 26 32 34 40 46 48 56
     ------------------------------------------------
        cos:  0  1  1  2  2  3  7  4  4  5  5  7  7
```

Configuring the Egress Queues

Note This feature is supported by both the SI and EI.

This section describes how to configure the egress queues:

- Configuring CoS Priority Queues, page 27-34
- Configuring WRR Priority, page 27-35
- Enabling the Expedite Queue and Configuring WRR Priority, page 27-35

For more information about the egress queues, see the "Egress CoS Queues" section on page 27-9.

Configuring CoS Priority Queues

Beginning in privileged EXEC mode, follow these steps to configure the CoS priority queues:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**wrr-queue cos-map** *qid cos1..cosn*	Specify the queue ID of the CoS priority queue. (Ranges are 1 to 4 where 1 is the lowest CoS priority queue.) Specify the CoS values that are mapped to the queue id. Default values are as follows: CoS Value — CoS Priority Queues 0, 1 — 1 2, 3 — 2 4, 5 — 3 6, 7 — 4
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show wrr-queue cos-map**	Display the mapping of the CoS priority queues.

To disable the new CoS settings and return to default settings, use the **no wrr-queue cos-map** global configuration command.

Configuring WRR Priority

Beginning in privileged EXEC mode, follow these steps to configure the WRR priority:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**wrr-queue bandwidth** *weight1...weight4*	Assign WRR weights to the four CoS queues. These are the ranges for the WRR values: • For *weight1*, *weight2*, and *weight3*, the range is 1 to 255. • For *weight4*, the range is 0 to 255. When weight4 is set to 0, queue 4 is configured as the expedite queue. **Note** In software releases earlier than Release 12.1(12c)EA1, the ranges for all queues is 1 to 255.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show wrr-queue bandwidth**	Display the WRR bandwidth allocation for the CoS priority queues.

To disable the WRR scheduling and enable the strict priority scheduling, use the **no wrr-queue bandwidth** global configuration command.

To enable one of the queues as the expedite queue and to enable the WRR scheduling for the remaining queues, see the "Enabling the Expedite Queue and Configuring WRR Priority" section on page 27-35.

Enabling the Expedite Queue and Configuring WRR Priority

In Release 12.1(12c)EA1 or later, beginning in privileged EXEC mode, follow these steps to enable the expedite queue (queue 4) and assign WRR priority to the remaining queues:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**wrr-queue bandwidth** *weight1 weight2 weight3* **0**	Configure queue 4 as the expedite queue and assign WRR weights to the remaining egress queues. The range of WRR weights for *weight1*, *weight2*, and *weight3* is 1 to 255.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show wrr-queue bandwidth**	Display the WRR bandwidth allocation for the CoS priority queues.

Displaying Standard QoS Information

To display standard QoS information, use one or more of the privileged EXEC commands in Table 27-8:

Table 27-8 Commands for Displaying QoS Information

Command	Purpose
show class-map [*class-map-name*][1]	Display QoS class maps, which define the match criteria to classify traffic.
show policy-map [*policy-map-name* [**class** *class-name*]][1]	Display QoS policy maps, which define classification criteria for incoming traffic.
show mls qos maps [**cos-dscp** | **dscp-cos**][1]	Display QoS mapping information. Maps are used to generate an internal DSCP value, which represents the priority of the traffic.
show mls qos interface [*interface-id*] [**policers**][1]	Display QoS information at the interface level, including the configuration of the egress queues and the CoS-to-egress-queue map, which interfaces have configured policers, and ingress and egress statistics (including the number of bytes dropped).
show mls masks [**qos** | **security**][1]	Display details regarding the masks[2] used for QoS and security ACLs.
show wrr-queue cos-map	Display the mapping of the CoS priority queues.
show wrr-queue bandwidth	Display the WRR bandwidth allocation for the CoS priority queues.

1. Available only on a switch running the EI.
2. Access control parameters are called masks in the switch CLI commands and output.

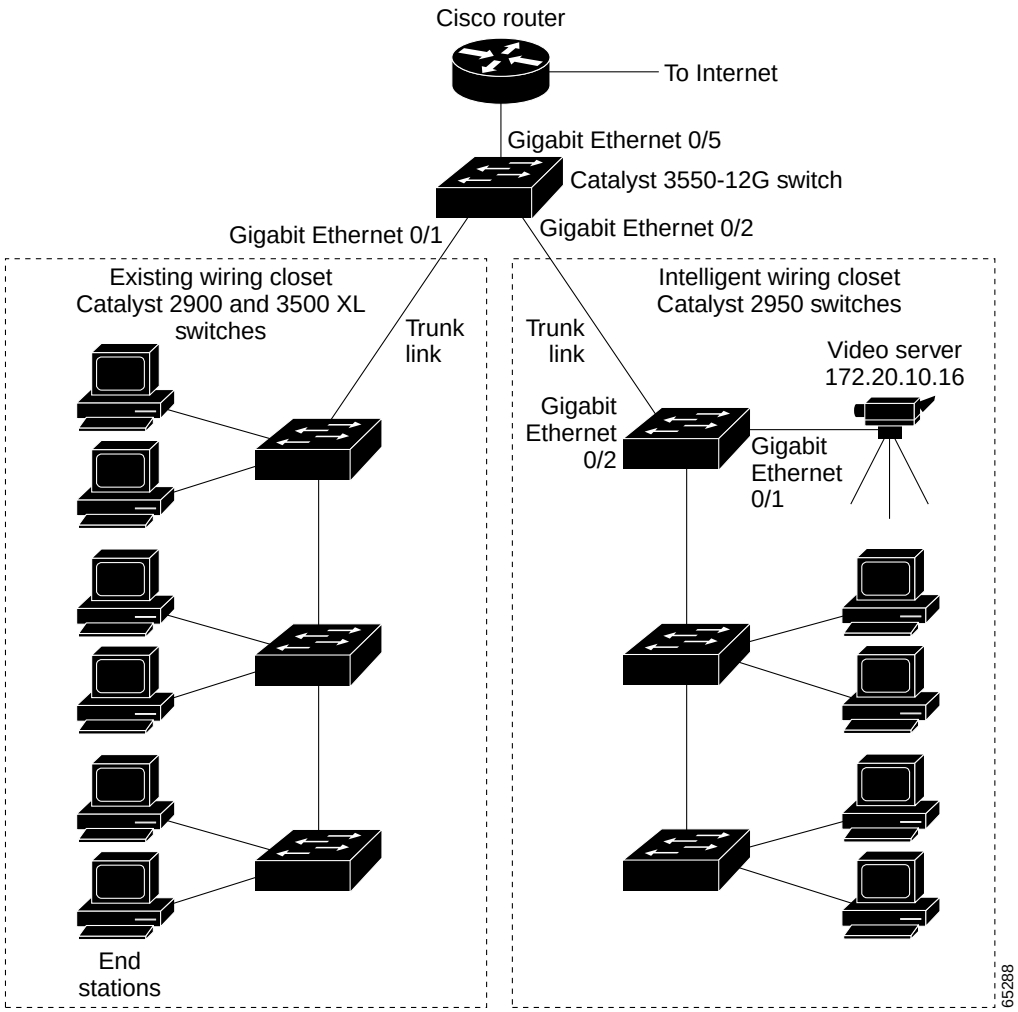
Standard QoS Configuration Examples

Note These examples are applicable only if your switch is running the EI.

This section shows a QoS migration path to help you quickly implement QoS features based on your existing network and planned changes to your network, as shown in Figure 27-5. It contains this information:

- QoS Configuration for the Existing Wiring Closet, page 27-37
- QoS Configuration for the Intelligent Wiring Closet, page 27-38

Figure 27-5 QoS Configuration Example Network



QoS Configuration for the Existing Wiring Closet

The existing wiring closet in Figure 27-5 consists of existing Catalyst 2900 XL and 3500 XL switches. These switches are running IOS release 12.0(5)XP or later, which supports the QoS-based IEEE 802.1P CoS values. QoS classifies frames by assigning priority-indexed CoS values to them and gives preference to higher-priority traffic.

Recall that on the Catalyst 2900 and 3500 XL switches, you can classify untagged (native) Ethernet frames at the ingress ports by setting a default CoS priority (**switchport priority default** *default-priority-id* interface configuration command) for each port. For IEEE 802.1Q frames with tag information, the priority value from the header frame is used. On the Catalyst 3524-PWR XL and 3548 XL switches, you can override this priority with the default value by using the **switchport priority default override** interface configuration command. For Catalyst 2950 and Catalyst 2900 XL switches and other 3500 XL models that do not have the override feature, the Catalyst 3550-12T switch at the distribution layer can override the 802.1P CoS value by using the **mls qos cos override** interface configuration command.

For the Catalyst 2900 and 3500 XL switches, CoS configures each transmit port (the egress port) with a normal-priority transmit queue and a high-priority transmit queue, depending on the frame tag or the port information. Frames in the normal-priority queue are forwarded only after frames in the high-priority queue are forwarded. Frames that have 802.1P CoS values of 0 to 3 are placed in the normal-priority transmit queue while frames with CoS values of 4 to 7 are placed in the expedite (high-priority) queue.

QoS Configuration for the Intelligent Wiring Closet

The intelligent wiring closet in Figure 27-5 is composed of Catalyst 2950 switches. One of the switches is connected to a video server, which has an IP address of 172.20.10.16.

The object of this example is to prioritize the video traffic over all other traffic. To do so, a DSCP of 46 is assigned to the video traffic. This traffic is stored in queue 4, which is serviced more frequently than the other queues.

Beginning in privileged EXEC mode, follow these steps to configure the switch to prioritize video packets over all other traffic:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**access-list 1 permit 172.20.10.16**	Define an IP standard ACL, and permit traffic from the video server at 172.20.10.16.
Step 3	**class-map videoclass**	Create a class map called *videoclass*, and enter class-map configuration mode.
Step 4	**match access-group 1**	Define the match criterion by matching the traffic specified by ACL 1.
Step 5	**exit**	Return to global configuration mode.
Step 6	**policy-map videopolicy**	Create a policy map called *videopolicy*, and enter policy-map configuration mode.
Step 7	**class videoclass**	Specify the class on which to act, and enter policy-map class configuration mode.
Step 8	**set ip dscp 46**	For traffic matching ACL 1, set the DSCP of incoming packets to 46.
Step 9	**police 5000000 8192 exceed-action drop**	Define a policer for the classified video traffic to drop traffic that exceeds 5-Mbps average traffic rate with an 8192-byte burst size.
Step 10	**exit**	Return to policy-map configuration mode.
Step 11	**exit**	Return to global configuration mode.
Step 12	**interface gigabitethernet0/1**	Enter interface configuration mode, and specify the ingress interface.
Step 13	**service-policy input videopolicy**	Apply the policy to the ingress interface.
Step 14	**exit**	Return to global configuration mode.
Step 15	**wrr-queue bandwidth 1 2 3 4**	Assign a higher WRR weight to queue 4.
Step 16	**wrr-queue cos-map 4 6 7**	Configure the CoS-to-egress-queue map so that CoS values 6 and 7 select queue 4.
Step 17	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 18	**show class-map videoclass** **show policy-map videopolicy** **show mls qos maps** [**cos-dscp** | **dscp-cos**]	Verify your entries.
Step 19	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

CHAPTER 28

Configuring EtherChannels

This chapter describes how to configure EtherChannel on the Layer 2 interfaces of a Catalyst 2950 or Catalyst 2955 switch. EtherChannel provides fault-tolerant high-speed links between switches, routers, and servers. You can use it to increase the bandwidth between the wiring closets and the data center, and you can deploy it anywhere in the network where bottlenecks are likely to occur. EtherChannel provides automatic recovery for the loss of a link by redistributing the load across the remaining links. If a link fails, EtherChannel redirects traffic from the failed link to the remaining links in the channel without intervention.

This chapter provides these topics about the Catalyst 2950 and Catalyst 2955 switch software:

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release.

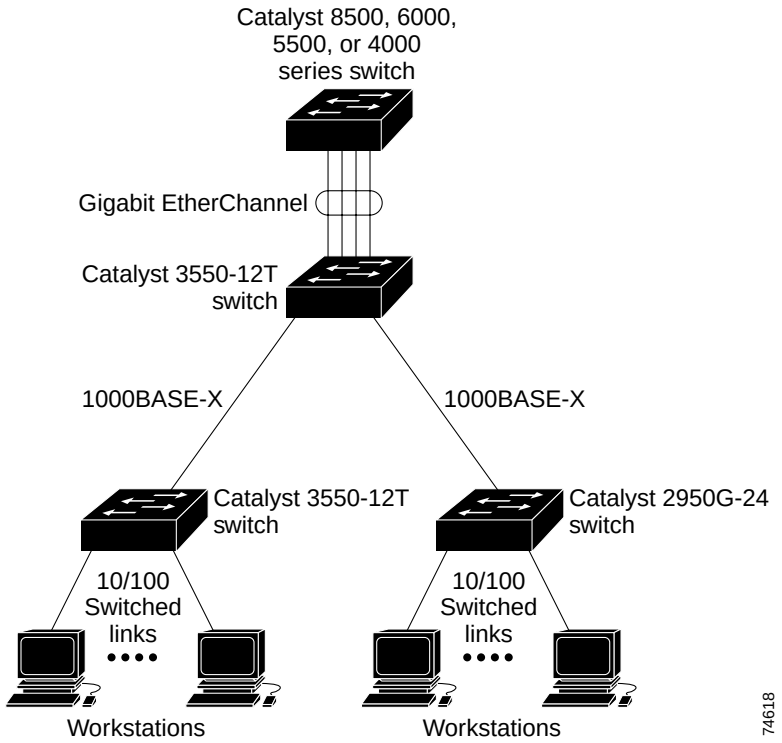
This chapter consists of these sections:

- Understanding EtherChannels, page 28-1
- Configuring EtherChannels, page 28-7
- Displaying EtherChannel, PAgP, and LACP Status, page 28-15

Understanding EtherChannels

An EtherChannel consists of individual Fast Ethernet or Gigabit Ethernet links bundled into a single logical link as shown in Figure 28-1. The EtherChannel provides full-duplex bandwidth up to 800 Mbps (Fast EtherChannel) or 2 Gbps (Gigabit EtherChannel) between your switch and another switch or host.

Figure 28-1 Typical EtherChannel Configuration



Each EtherChannel can consist of up to eight compatibly configured Ethernet interfaces. All interfaces in each EtherChannel must be the same speed, and all must be configured as Layer 2 interfaces.

Note The network device to which your switch is connected can impose its own limits on the number of interfaces in the EtherChannel. For Catalyst 2950 and Catalyst 2955 switches, the number of EtherChannels is limited to six with eight ports per EtherChannel.

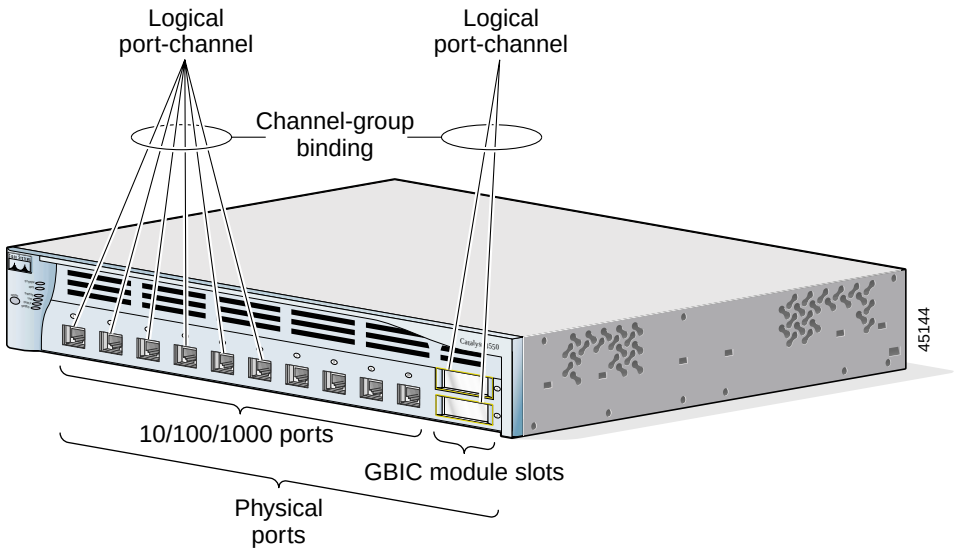
If a link within an EtherChannel fails, traffic previously carried over that failed link changes to the remaining links within the EtherChannel. A trap is sent for a failure, identifying the switch, the EtherChannel, and the failed link. Inbound broadcast and multicast packets on one link in an EtherChannel are blocked from returning on any other link of the EtherChannel.

Understanding Port-Channel Interfaces

When you create an EtherChannel for Layer 2 interfaces, a logical interface is dynamically created. You then manually assign an interface to the EtherChannel by using the **channel-group** interface configuration command as shown in Figure 28-2.

Each EtherChannel has a logical port-channel interface numbered from 1 to 6.

Figure 28-2 Relationship of Physical Ports, Logical Port Channels, and Channel Groups



When a port joins an EtherChannel, the physical interface for that port is shut down. When the port leaves the port-channel, its physical interface is brought up, and it has the same configuration as it had before joining the EtherChannel.

Note Configuration changes made to the logical interface of an EtherChannel do not propagate to all the member ports of the channel.

Understanding the Port Aggregation Protocol and Link Aggregation Protocol

The Port Aggregation Protocol (PAgP) and Link Aggregation Control Protocol (LACP) facilitate the automatic creation of EtherChannels by exchanging packets between Ethernet interfaces. PAgP is a Cisco-proprietary protocol that can be run only on Cisco switches and on those switches licensed by licensed vendors to support PAgP. LACP is defined in IEEE 802.3AD and allows Cisco switches to manage Ethernet channels between switches that conform to the 802.3AD protocol.

By using one of these protocols, a switch learns the identity of partners capable of supporting either PAgP or LACP and learns the capabilities of each interface. It then dynamically groups similarly configured interfaces into a single logical link (channel or aggregate port); these interfaces are grouped based on hardware, administrative, and port parameter constraints. For example, PAgP groups the interfaces with the same speed, duplex mode, native VLAN, VLAN range, and trunking status and type. After grouping the links into an EtherChannel, PAgP adds the group to the spanning tree as a single switch port.

PAgP and LACP Modes

Table 28-1 shows the user-configurable EtherChannel modes for the **channel-group** interface configuration command. Switch interfaces exchange PAgP packets only with partner interfaces configured in the **auto** or **desirable** modes. Switch interfaces exchange LACP packets only with partner interfaces configured in the **active** or **passive** modes. Interfaces configured in the **on** mode do not exchange PAgP or LACP packets.

Table 28-1 EtherChannel Modes

Mode	Description
active	Places an interface into an active negotiating state, in which the interface starts negotiations with other interfaces by sending LACP packets.
auto	Places an interface into a passive negotiating state, in which the interface responds to PAgP packets it receives but does not start PAgP packet negotiation. This setting minimizes the transmission of PAgP packets.
desirable	Places an interface into an active negotiating state, in which the interface starts negotiations with other interfaces by sending PAgP packets.
on	Forces the interface into an EtherChannel without PAgP or LACP. With the **on** mode, a usable EtherChannel exists only when an interface group in the **on** mode is connected to another interface group in the **on** mode.
passive	Places an interface into a passive negotiating state, in which the interface responds to LACP packets that it receives, but does not start LACP packet negotiation. This setting minimizes the transmission of LACP packets.

Exchanging PAgP Packets

Both the **auto** and **desirable** PAgP modes allow interfaces to negotiate with partner interfaces to determine if they can form an EtherChannel based on criteria such as interface speed and, for Layer 2 EtherChannels, trunking state and VLAN numbers.

Interfaces can form an EtherChannel when they are in different PAgP modes as long as the modes are compatible. For example:

- An interface in the **desirable** mode can form an EtherChannel with another interface that is in the **desirable** or **auto** mode.
- An interface in the **auto** mode can form an EtherChannel with another interface in the **desirable** mode.

An interface in the **auto** mode cannot form an EtherChannel with another interface that is also in the **auto** mode because neither interface starts PAgP negotiation.

An interface in the **on** mode that is added to a port channel is forced to have the same characteristics as the already existing **on** mode interfaces in the channel.

If your switch is connected to a partner that is PAgP-capable, you can configure the switch interface for nonsilent operation by using the **non-silent** keyword. If you do not specify **non-silent** with the **auto** or **desirable** mode, silent mode is assumed.

The silent mode is used when the switch is connected to a device that is not PAgP-capable and seldom, if ever, sends packets. An example of a silent partner is a file server or a packet analyzer that is not generating traffic. In this case, running PAgP on a physical port connected to a silent partner prevents that switch port from ever becoming operational; however, the silent setting allows PAgP to operate, to attach the interface to a channel group, and to use the interface for transmission.

Note An Etherchannel cannot be configured in both the PAgP and LACP modes.

Exchanging LACP Packets

Both the **active** and **passive** LACP modes allow interfaces to negotiate with partner interfaces to determine if they can form an EtherChannel based on criteria such as interface speed and, for Layer 2 EtherChannels, trunking state and VLAN numbers.

Interfaces can form an EtherChannel when they are in different LACP modes as long as the modes are compatible. For example:

- An interface in the **active** mode can form an EtherChannel with another interface that is in the **active** or **passive** mode.
- An interface in the **active** mode can form an EtherChannel with another interface in the **passive** mode.

An interface in the **passive** mode cannot form an EtherChannel with another interface that is also in the **passive** mode because neither interface starts LACP negotiation.

An interface in the **on** mode that is added to a port channel is forced to have the same characteristics as the already existing **on** mode interfaces in the channel.

Note An Etherchannel cannot be configured in both the PAgP and LACP modes.

Caution You should exercise care when setting the mode to **on** (manual configuration). All ports configured in the **on** mode are bundled in the same group and are forced to have similar characteristics. If the group is misconfigured, packet loss or spanning-tree loops might occur.

Physical Learners and Aggregate-Port Learners

Network devices are classified as PAgP physical learners or aggregate-port learners. A device is a physical learner if it learns addresses by physical ports and directs transmissions based on that knowledge. A device is an aggregate-port learner if it learns addresses by aggregate (logical) ports.

When a device and its partner are both aggregate-port learners, they learn the address on the logical port-channel. The device sends packets to the source by using any of the interfaces in the EtherChannel. With aggregate-port learning, it is not important on which physical port the packet arrives.

The switch uses source-MAC address distribution for a channel if it is connected to a physical learner even if you configure the switch for destination-MAC address distribution.

These frame distribution mechanisms are possible for frame transmission:

- Port selection based on the source-MAC address of the packet
- Port selection based on the destination- MAC address of the packet

The switch supports up to eight ports in a PAgP group.

PAgP and LACP Interaction with Other Features

The Dynamic Trunking Protocol (DTP) and Cisco Discovery Protocol (CDP) send and receive packets over the physical interfaces in the EtherChannel. Trunk ports send and receive PAgP and LACP protocol data units (PDUs) on the lowest numbered VLAN.

Spanning tree sends packets over a single physical interface in the EtherChannel. Spanning tree regards the EtherChannel as one port.

PAgP sends and receives PAgP PDUs only from interfaces that have PAgP enabled for the auto or desirable mode. LACP sends and receives LACP PDUs only from interfaces that have LACP enabled for the active or passive mode.

Understanding Load Balancing and Forwarding Methods

EtherChannel balances the traffic load across the links in a channel by randomly associating a newly-learned MAC address with one of the links in the channel.

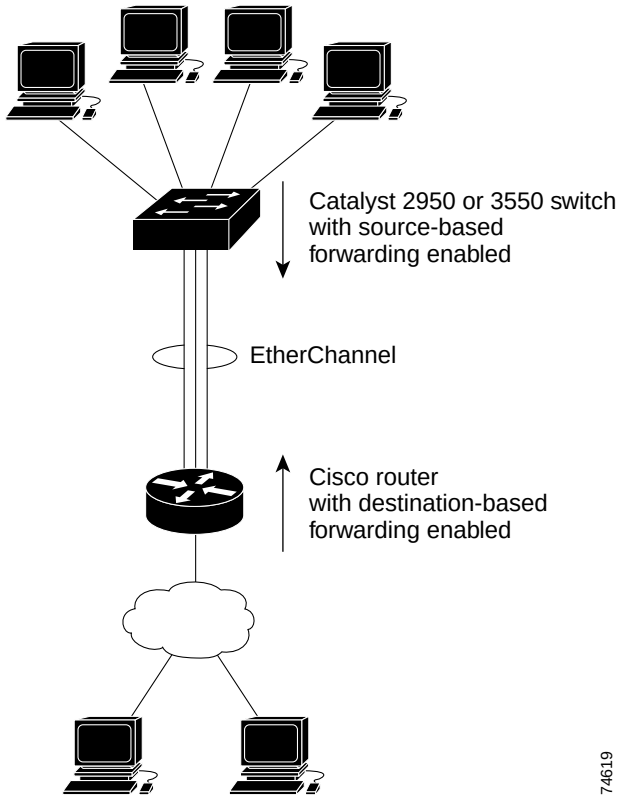
With source-MAC address forwarding, when packets are forwarded to an EtherChannel, they are distributed across the ports in the channel based on the source-MAC address of the incoming packet. Therefore, to provide load balancing, packets from different hosts use different ports in the channel, but packets from the same host use the same port in the channel (and the MAC address learned by the switch does not change).

With destination-MAC address forwarding, when packets are forwarded to an EtherChannel, they are distributed across the ports in the channel based on the destination host's MAC address of the incoming packet. Therefore, packets to the same destination are forwarded over the same port, and packets to a different destination are sent on a different port in the channel. You configure the load balancing and forwarding method by using the **port-channel load-balance** global configuration command.

In Figure 28-3, multiple workstations are connected to a switch, and an EtherChannel connects the switch to the router. Source-based load balancing is used on the switch end of the EtherChannel to ensure that the switch efficiently uses the bandwidth of the router by distributing traffic from the workstation across the physical links. Since the router is a single MAC address device, it uses destination-based load balancing to efficiently spread the traffic to the workstations across the physical links in the EtherChannel.

Use the option that provides the greatest variety in your configuration. For example, if the traffic on a channel is going only to a single MAC address, using the destination-MAC address always chooses the same link in the channel; using source addresses or IP addresses might result in better load balancing.

Figure 28-3 Load Distribution and Forwarding Methods



Configuring EtherChannels

These sections describe how to configure EtherChannel interfaces:

- Default EtherChannel Configuration, page 28-8
- EtherChannel Configuration Guidelines, page 28-8
- Configuring Layer 2 EtherChannels, page 28-9
- Configuring EtherChannel Load Balancing, page 28-11
- Configuring the PAgP Learn Method and Priority, page 28-12

Note Make sure that the interfaces are correctly configured (see the "EtherChannel Configuration Guidelines" section on page 28-8).

Note After you configure an EtherChannel, configuration changes applied to the port-channel interface apply to all the physical interfaces assigned to the port-channel interface, and configuration changes applied to the physical interface affect only the interface where you apply the configuration.

Default EtherChannel Configuration

Table 28-2 shows the default EtherChannel configuration.

Table 28-2 Default EtherChannel Configuration

Feature	Default Setting
Channel groups	None assigned.
PAgP mode	No default.
PAgP learn method	Aggregate-port learning on all interfaces.
PAgP priority	128 on all interfaces. (Changing this value has no effect.)
LACP learn method	Aggregate-port learning on all interfaces.
LACP priority	32768 on all interfaces.
Load balancing	Load distribution on the switch is based on the source-MAC address of the incoming packet.

EtherChannel Configuration Guidelines

If improperly configured, some EtherChannel interfaces are automatically disabled to avoid network loops and other problems. Follow these guidelines to avoid configuration problems:

- Configure an EtherChannel with up to eight Ethernet interfaces of the same type.

  Note Do not configure a GigaStack GBIC port as part of an EtherChannel.

- Configure all interfaces in an EtherChannel to operate at the same speeds and duplex modes.
- Enable all interfaces in an EtherChannel. An interface in an EtherChannel that is disabled by using the **shutdown** interface configuration command is treated as a link failure, and its traffic is transferred to one of the remaining interfaces in the EtherChannel.
- When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, you must also make the changes to all ports in the group:
  - Allowed-VLAN list
  - Spanning-tree path cost for each VLAN
  - Spanning-tree port priority for each VLAN
  - Spanning-tree Port Fast setting
- Do not configure a port that belongs to an EtherChannel port group as a secure port.
- Before enabling 802.1X on the port, you must first remove it from the EtherChannel. If you try to enable 802.1X on an EtherChannel or on an active port in an EtherChannel, an error message appears, and 802.1X is not enabled. If you enable 802.1X on a not-yet active port of an EtherChannel, the port does not join the EtherChannel.
- An EtherChannel supports the same allowed range of VLANs on all the interfaces in a trunking Layer 2 EtherChannel. When configuring an interface for PAgP, if the allowed range of VLANs is not the same, the interfaces do not form an EtherChannel even when PAgP is set to the **auto** or

desirable mode. When configuring an interface for LACP, if the allowed range of VLANs is not the same, the interfaces do not form an EtherChannel even when LACP is set to the **active** or **passive** mode

- Interfaces with different spanning-tree path costs can form an EtherChannel if they are otherwise compatibly configured. Setting different spanning-tree path costs does not, by itself, make interfaces incompatible for the formation of an EtherChannel.

Configuring Layer 2 EtherChannels

You configure Layer 2 EtherChannels by configuring the Ethernet interfaces with the **channel-group** interface configuration command, which creates the port-channel logical interface. You cannot put a Layer 2 interface into a manually created port-channel interface.

Note Layer 2 interfaces must be connected and functioning for IOS to create port-channel interfaces.

Beginning in privileged EXEC mode, follow these steps to assign a Layer 2 Ethernet interface to a Layer 2 EtherChannel:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify a physical interface to configure. Valid interfaces include physical interfaces. Up to eight interfaces of the same type and speed can be configured for the same group.

	Command	Purpose
Step 3	**channel-group** *channel-group-number* **mode** {{**auto** [**non-silent**] | **desirable** [**non-silent**] | **on**} | {**active** | **passive**}}	Assign the interface to a channel group, and specify the PAgP or LACP mode. For *channel-group-number*, the range is 1 to 6. Each EtherChannel can have up to eight compatibly configured Ethernet interfaces. For **mode**, select one of these keywords: • **active—**Enables LACP only if an LACP device is detected. It places an interface into an active negotiating state, in which the interface starts negotiations with other interfaces by sending LACP packets. • **auto**—Enables PAgP only if a PAgP device is detected. It places an interface into a passive negotiating state, in which the interface responds to PAgP packets it receives but does not start PAgP packet negotiation. • **desirable**—Unconditionally enables PAgP. It places an interface into an active negotiating state, in which the interface starts negotiations with other interfaces by sending PAgP packets. • **on**—Forces the interface to channel without PAgP. With the **on** mode, a usable EtherChannel exists only when an interface group in the **on** mode is connected to another interface group in the **on** mode. • **non-silent**—If your switch is connected to a partner that is PAgP-capable, you can configure the switch interface for nonsilent operation. You can configure an interface with the **non-silent** keyword for use with the **auto** or **desirable** mode. If you do not specify **non-silent** with the **auto** or **desirable** mode, silent is assumed. The silent setting is for connections to file servers or packet analyzers. This setting allows PAgP to operate, to attach the interface to a channel group, and to use the interface for transmission. • **passive**—Enables LACP on an interface and places it into a passive negotiating state, in which the interface responds to LACP packets that it receives, but does not start LACP packet negotiation. For information on compatible PAgP and LACP modes for the switch and its partner, see the "PAgP and LACP Modes" section on page 28-3.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove an interface from the EtherChannel group, use the **no channel-group** interface configuration command. If you delete the EtherChannel by using the **no interface port-channel** global configuration command without removing the physical interfaces, the physical interfaces are shutdown. If you do not want the member physical interfaces to shut down, remove the physical interfaces before deleting the EtherChannel.

This example shows how to assign Gigabit Ethernet interfaces 0/1 and 0/2 with the PAgP mode **desirable**:

```
Switch# configure terminal
Switch(config)# interface range gigabitethernet0/1 -2
Switch(config-if)# channel-group 5 mode desirable
Switch(config-if)# end
```

Configuring EtherChannel Load Balancing

This section describes how to configure EtherChannel load balancing by using source-based or destination-based forwarding methods. For more information, see the "Understanding Load Balancing and Forwarding Methods" section on page 28-6.

Beginning in privileged EXEC mode, follow these steps to configure EtherChannel load balancing:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**port-channel load-balance** {**dst-mac** | **src-mac**}	Configure an EtherChannel load-balancing method. The default is **src-mac**. Select one of these keywords to determine the load-distribution method: • **dst-mac**—Load distribution is based on the destination-host MAC address of the incoming packet. Packets to the same destination are sent on the same port, but packets to different destinations are sent on different ports in the channel. • **src-mac**—Load distribution is based on the source-MAC address of the incoming packet. Packets from different hosts use different ports in the channel, but packets from the same host use the same port in the channel. If the link partner to the switch is a physical learner, set the load-distribution method to one of these ways: • If the **channel-group** interface configuration command is set to **auto** or **desirable**, the switch automatically uses the load distribution method based on the source-MAC address, regardless of the configured load-distribution method. • If the **channel-group** interface configuration command is set to **on**, set the load-distribution method based on the source-MAC address by using the **port-channel load-balance src-mac** global configuration command.
Step 3	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 4	**show etherchannel load-balance**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To return EtherChannel load balancing to the default configuration, use the **no port-channel load-balance** global configuration command.

Configuring the PAgP Learn Method and Priority

Network devices are classified as PAgP physical learners or aggregate-port learners. A device is a physical learner if it learns addresses by physical ports and directs transmissions based on that knowledge. A device is an aggregate-port learner if it learns addresses by aggregate ports.

For compatibility with Catalyst 1900 series switches, configure the Catalyst 2950 and Catalyst 2955 switches for source-MAC load distribution.

The Catalyst 2950 or Catalyst 2955 switch supports address learning only on aggregate ports even though the **physical-port** keyword is provided in the command-line interface (CLI). The **pagp learn-method** and the **pagp port-priority** interface configuration command have no effect on the switch hardware.

Note You should not set the learn method to **physical-port** because the switch is an aggregate-learning device.

If the link partner to the switch is a physical learner that has the **channel-group** interface configuration command set to **auto** or **desirable**, the switch automatically uses the load-distribution method based on the source MAC address, regardless of the configured load distribution method.

If the link partner to the Catalyst 2950 or Catalyst 2955 switch is a physical learner that has the **channel-group** interface configuration command set to **on**, set the load-distribution method based on the source MAC address by using the **port-channel load-balance src-mac** global configuration command.

Configuring the LACP Port Priority

You can set the priority for each port in an EtherChannel that is configured for LACP by using the **lacp port-priority** privileged EXEC command. The range is from 1 to 65535. Beginning in privileged EXEC mode, follow these steps to configure the LACP port priority:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface for transmission.
Step 3	**lacp port-priority** *priority-value*	Select the LACP port priority value. For priority-value, the range is 1 to 65535. By default, the priority value is 32768. The lower the range, the more likely that the interface will be used for LACP transmission.
Step 4	**end**	Return to privileged EXEC mode.

	Command	Purpose
Step 5	**show running-config** or **show lacp** *channel-group-number* **internal**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Configuring Hot Standby Ports

When enabled, LACP tries to configure the maximum number of LACP-compatible ports in a channel, up to a maximum of 16 ports. Only eight LACP links can be active at one time. Any additional links are put in a hot standby state. If one of the active links becomes inactive, a link that is in hot standby mode becomes active in its place.

If more than eight links are configured for an EtherChannel group, the software determines which of the hot standby ports to make active based on:

- LACP port-priority
- Port ID

All ports default to the same port priority. You can change the port priority of LACP EtherChannel ports to specify which hot standby links become active first by using the **lacp port-priority** interface configuration command to set the port priority to a value lower than the default of 32768.

The hot standby ports that have lower port numbers become active in the channel first unless the port priority is configured to be a lower number than the default value of 32768.

Note If LACP is not able to aggregate all the ports that are compatible (for example, the remote system might have more restrictive hardware limitations), all the ports that cannot be actively included in the EtherChannel are put in hot standby state and are used only if one of the channeled ports fails.

Configuring the LACP System Priority

You can set the system priority for all of the EtherChannels that are configured for LACP by using the **lacp system-priority** privileged EXEC command. The range is from 1 to 65535.

Note The **lacp system-priority** command is global. You cannot set a system priority for each LACP-configured channel separately.

We recommend using this command only when there are a combination of LACP-configured EtherChannels that are in both **active** and **standby** modes.

Beginning in privileged EXEC mode, follow these steps to configure the LACP system priority:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**lacp system-priority** *priority-value*	Select the LACP system priority value. For priority-value, the range is 1 to 65535. By default, the priority value is 32768. The lower the range, the higher the system priority. The switch with the lower system priority value determines which links between LACP partner switches are active and which are in standby for each LACP EtherChannel.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config** or **show lacp** *channel-group-number* **internal**	Verify your entries.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Displaying EtherChannel, PAgP, and LACP Status

You can use the privileged EXEC commands described in Table 28-3 to display EtherChannel, PAgP, and LACP status information:

Table 28-3 Commands for Displaying EtherChannel, PAgP, and LACP Status

Command	Description
show etherchannel [*channel-group-number*] {**brief** | **detail** | **load-balance** | **port** | **port-channel** | **summary**}	Displays EtherChannel information in a brief, detailed, and one-line summary form. Also displays the load-balance or frame-distribution scheme, port, and port-channel information.
show pagp [*channel-group-number*] {**counters** | **internal** | **neighbor**}[1]	Displays PAgP information such as traffic information, the internal PAgP configuration, and neighbor information.
show lacp [*channel-group-number*] {**counters** | **internal** | **neighbor**}[2]	Displays LACP information such as traffic information, the internal PAgP configuration, and neighbor information.

1. You can clear PAgP channel-group information and traffic filters by using the **clear pagp** {*channel-group-number* [**counters**] | **counters**} privileged EXEC command.
2. You can clear LACP channel-group information and traffic filters by using the **clear lacp** {*channel-group-number* [**counters**] | **counters**} privileged EXEC command.

For detailed information about the fields in the command outputs, refer to the command reference for this release.

Troubleshooting

This chapter describes how to identify and resolve Catalyst 2950 and Catalyst 2955 software problems related to the IOS software. Depending on the nature of the problem, you can use the command-line interface (CLI) or the Cluster Management Suite (CMS) to identify and solve problems. To identify and resolve Cisco-approved Course Wave Division Multiplexer (CWDM) Gigabit Interface Converter (GBIC) problems, you must have the enhanced software image (EI) installed on your Catalyst 2950 switch.

Note For complete syntax and usage information for the commands used in this chapter, refer to the command reference for this release and the *Cisco IOS Command Summary for Release 12.1*.

This chapter consists of these sections:

- Using Recovery Procedures, page 29-1
- Preventing Autonegotiation Mismatches, page 29-10
- GBIC Module Security and Identification, page 29-10
- Diagnosing Connectivity Problems, page 29-11
- Using Debug Commands, page 29-14
- Using the crashinfo File, page 29-17

Using Recovery Procedures

These recovery procedures require that you have physical access to the switch:

- Recovering from Corrupted Software, page 29-2
- Recovering from a Lost or Forgotten Password, page 29-2
- Recovering from a Lost or Forgotten Password on the Catalyst 2955 Switch, page 29-4
- Recovering from a Command Switch Failure, page 29-6
- Recovering from Lost Member Connectivity, page 29-10

Recovering from Corrupted Software

Switch software can be corrupted during an upgrade, by downloading the wrong file to the switch, and by deleting the image file. In all of these cases, the switch does not pass the power-on self-test (POST), and there is no connectivity.

This procedure uses the XMODEM protocol to recover from a corrupt or wrong image file. There are many software packages that support the XMODEM protocol, and this procedure is largely dependent on the emulation software you are using.

Follow these steps to recover from corrupted software:

Step 1 Connect a PC with terminal-emulation software supporting the XMODEM protocol to the switch console port.

Step 2 Set the line speed on the emulation software to 9600 baud.

Step 3 Disconnect the switch power cord.

Step 4 Reconnect the power cord to the switch.

The software image does not load. The switch starts in boot loader mode, which is indicated by the `switch#` prompt.

Step 5 Use the boot loader to enter commands, and start the transfer.

```
switch# copy xmodem: flash:image_filename.bin
```

Step 6 When the XMODEM request appears, use the appropriate command on the terminal-emulation software to start the transfer and to copy the software image to Flash memory.

Recovering from a Lost or Forgotten Password

Note For instructions on how to recover a lost or forgotten password on a Catalyst 2955 switch, see the "Recovering from a Lost or Forgotten Password on the Catalyst 2955 Switch" section on page 29-4.

Follow these steps if you have forgotten or lost the switch password.

Step 1 Connect a terminal or PC with terminal emulation software to the console port. For more information, refer to the switch hardware installation guide.

Note You can configure your switch for Telnet by following the procedure in the "Accessing the CLI" section on page 2-9.

Step 2 Set the line speed on the emulation software to 9600 baud.

Step 3 Unplug the switch power cord.

Step 4 Press the **Mode** button, and at the same time, reconnect the power cord to the switch.

You can release the **Mode** button a second or two after the LED above port 1X turns off. Several lines of information about the software appear, as do instructions:

```
The system has been interrupted prior to initializing the flash file system. These
commands will initialize the flash file system, and finish loading the operating system
software:

flash_init
load_helper
boot
```

Step 5 Initialize the Flash file system:

```
switch# flash_init
```

Step 6 If you had set the console port speed to anything other than 9600, it has been reset to that particular speed. Change the emulation software line speed to match that of the switch console port.

Step 7 Load any helper files:

```
switch# load_helper
```

Step 8 Display the contents of Flash memory as in this example:

```
switch# dir flash:
The switch file system is displayed:
Directory of flash:/
  3  drwx       10176   Mar 01 2001 00:04:34  html
  6  -rwx        2343   Mar 01 2001 03:18:16  config.text
171  -rwx     1667997   Mar 01 2001 00:02:39  c2950-i6q412-mz.121-9.EA1.bin
  7  -rwx        3060   Mar 01 2001 00:14:20  vlan.dat
172  -rwx         100   Mar 01 2001 00:02:54  env_vars

7741440 bytes total (3884509 bytes free)
```

Step 9 Rename the configuration file to config.text.old.

This file contains the password definition.

```
switch# rename flash:config.text flash:config.text.old
```

Step 10 Boot the system:

```
switch# boot
```

You are prompted to start the setup program. Enter **N** at the prompt:

```
Continue with the configuration dialog? [yes/no]: N
```

Step 11 At the switch prompt, change to privileged EXEC mode:

```
switch> enable
```

Step 12 Rename the configuration file to its original name:

```
switch# rename flash:config.text.old flash:config.text
```

Step 13 Copy the configuration file into memory:

```
switch# copy flash:config.text system:running-config
Source filename [config.text]?
Destination filename [running-config]?
```

Press **Return** in response to the confirmation prompts.

The configuration file is now reloaded, and you can use the following normal commands to change the password.

Step 14 Enter global configuration mode:

```
switch# configure terminal
```

Step 15 Change the password:

```
switch(config)# enable secret <password>
```

or

```
switch(config)# enable password <password>
```

Step 16 Return to privileged EXEC mode:

```
switch(config)# exit
switch#
```

Step 17 Write the running configuration to the startup configuration file:

```
switch# copy running-config startup-config
```

The new password is now included in the startup configuration.

Recovering from a Lost or Forgotten Password on the Catalyst 2955 Switch

The Catalyst 2955 switch boot loader uses break key detection to stop the automatic boot sequence for the password recovery purpose.

Note The break key character is different for each operating system.

On a SUN work station running UNIX, Ctrl-C is the break key.

On a PC running Windows 2000, Ctrl-Break is the break key.

Cisco TAC has tabulated break keys for most common operating systems and an alternative *break key sequence* for those terminal emulators that do not support the break keys. Refer to http://www.cisco.com/warp/public/701/61.html#how-to for that list.

Step 1 Connect a terminal or PC with terminal emulation software to the console port. For more information, refer to the switch hardware installation guide.

Note You can configure your switch for Telnet by following the procedure in the "Accessing the CLI" section on page 2-9.

Step 2 Set the line speed on the emulation software to 9600 baud.

Step 3 Connect the power cord to the switch, and apply power to the switch.

After the switch performs POST, the switch begins the autoboot process. The boot loader prompts the user for a break key character during the boot-up sequence, as shown in this example:

```
***** The system will autoboot in 15 seconds *****

Send a break key to prevent autobooting.
```

Step 4 When the boot loader prompts you, enter the break key.

The following example displays the messages that appear on the console after the user enters a break key:

```
 The system has been interrupted prior to initializing the flash file system.
The following commands will initialize the flash file system, and finish loading
 the operating system software:

 flash_init
 load_helper
 boot
```

After a the message diplays, the boot loader prompt resumes.

On the Catalyst 2955C-12 and Catalyst 2955S-12, the PORT 13 LED flashes green and the PORT 14 LED is off during the initial appearance of the boot loader prompt on the console. On the Catalyst 2955T-12, the PORT 1 LED flashes green and the PORT 2 LED is off during the initial appearance of the boot loader prompt on the console.

Step 5 Initialize the Flash file system:

```
switch# flash_init
```

Step 6 If you set the console port speed to anything other than 9600, it has been reset to that particular speed. Change the emulation software line speed to match that of the switch console port.

Step 7 Load any helper files:

```
switch# load_helper
```

Step 8 Display the contents of Flash memory as in this example:

```
switch# dir flash:
The switch file system is displayed:
Directory of flash:/
  3  drwx       10176   Mar 01 2001 00:04:34  html
  6  -rwx        2343   Mar 01 2001 03:18:16  config.text
171  -rwx     1667997   Mar 01 2001 00:02:39  c2950-i6q412-mz.121-9.EA1.bin
  7  -rwx        3060   Mar 01 2001 00:14:20  vlan.dat
172  -rwx         100   Mar 01 2001 00:02:54  env_vars

7741440 bytes total (3884509 bytes free)
```

Step 9 Rename the configuration file to config.text.old.

This file contains the password definition.

```
switch# rename flash:config.text flash:config.text.old
```

Step 10 Boot the system:

```
switch# boot
```

You are prompted to start the setup program. Enter **N** at the prompt:

```
Continue with the configuration dialog? [yes/no]: N
```

Step 11 At the switch prompt, change to privileged EXEC mode:

```
switch> enable
```

Step 12 Rename the configuration file to its original name:

```
switch# rename flash:config.text.old flash:config.text
```

Step 13 Copy the configuration file into memory:

```
switch# copy flash:config.text system:running-config
Source filename [config.text]?
Destination filename [running-config]?
```

Press **Return** in response to the confirmation prompts.

The configuration file is now reloaded, and you can use these normal commands to change the password.

Step 14 Enter global configuration mode:

```
switch# configure terminal
```

Step 15 Change the password:

```
switch(config)# enable secret <password>
```

or

```
switch(config)# enable password <password>
```

Step 16 Return to privileged EXEC mode:

```
switch(config)# exit
switch#
```

Step 17 Write the running configuration to the startup configuration file:

```
switch# copy running-config startup-config
```

The new password is now included in the startup configuration.

Recovering from a Command Switch Failure

This section describes how to recover from a failed command switch. You can configure a redundant command switch group by using the Hot Standby Router Protocol (HSRP). For more information, see Chapter 7, "Clustering Switches."

Note HSRP is the preferred method for supplying redundancy to a cluster.

If you have not configured a standby command switch, and your command switch loses power or fails in some other way, management contact with the member switches is lost, and you must install a new command switch. However, connectivity between switches that are still connected is not affected, and the member switches forward packets as usual. You can manage the members as standalone switches through the console port or, if they have IP addresses, through the other management interfaces.

You can prepare for a command switch failure by assigning an IP address to a member switch or another switch that is command-capable, making a note of the command-switch password, and cabling your cluster to have redundant connectivity between the member switches and the replacement command switch. This section describes two solutions for replacing a failed command switch:

- Replacing a failed command switch with a cluster member
- Replacing a failed command switch with another switch

For information on command-capable switches, refer to the release notes.

Replacing a Failed Command Switch with a Cluster Member

To replace a failed command switch with a command-capable member in the same cluster, follow these steps:

Step 1 Disconnect the command switch from the member switches, and physically remove it from the cluster.

Step 2 Insert the member switch in place of the failed command switch, and duplicate its connections to the cluster members.

Step 3 Start a CLI session on the new command switch.

You can access the CLI by using the console port or, if an IP address has been assigned to the switch, by using Telnet. For details about using the console port, refer to the switch hardware installation guide.

Step 4 At the switch prompt, enter privileged EXEC mode:

```
Switch> enable
Switch#
```

Step 5 Enter the password of the *failed command switch*.

Step 6 Enter global configuration mode.

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

Step 7 Remove the member switch from the cluster.

```
Switch(config)# no cluster commander-address
```

Step 8 Return to privileged EXEC mode.

```
Switch(config)# end
Switch#
```

Step 9 Use the setup program to configure the switch IP information. This program prompts you for IP address information and passwords. From privileged EXEC mode, enter **setup**, and press **Return**.

```
Switch# setup
         --- System Configuration Dialog ---
Continue with configuration dialog? [yes/no]: y

At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.

Basic management setup configures only enough connectivity
for management of the system, extended setup will ask you
to configure each interface on the system

Would you like to enter basic management setup? [yes/no]:
```

Step 10 Enter **Y** at the first prompt.

The prompts in the setup program vary depending on the member switch you selected to be the command switch:

```
Continue with configuration dialog? [yes/no]: y
```

or

```
Configuring global parameters:
```

If this prompt does not appear, enter **enable**, and press **Return**. Enter **setup**, and press **Return** to start the setup program.

Step 11 Respond to the questions in the setup program.

When prompted for the host name, recall that on a command switch, the host name is limited to 28 characters; on a member switch to 31 characters. Do not use *-n*, where *n* is a number, as the last characters in a host name for any switch.

When prompted for the Telnet (virtual terminal) password, recall that it can be from 1 to 25 alphanumeric characters, is case sensitive, allows spaces, but ignores leading spaces.

Step 12 When prompted for the **enable secret** and **enable** passwords, enter the passwords of the *failed command switch* again.

Step 13 When prompted, make sure to enable the switch as the cluster command switch, and press **Return**.

Step 14 When prompted, assign a name to the cluster, and press **Return**.

The cluster name can be 1 to 31 alphanumeric characters, dashes, or underscores.

Step 15 After the initial configuration appears, verify that the addresses are correct.

Step 16 If the displayed information is correct, enter **Y**, and press **Return**.

If this information is not correct, enter **N**, press **Return**, and begin again at Step 9.

Step 17 Start your browser, and enter the IP address of the new command switch.

Step 18 From the Cluster menu, select **Add to Cluster** to display a list of candidate switches to add to the cluster.

Replacing a Failed Command Switch with Another Switch

To replace a failed command switch with a switch that is command-capable but not part of the cluster, follow these steps:

Step 1 Insert the new switch in place of the failed command switch, and duplicate its connections to the cluster members.

Step 2 Start a CLI session on the new command switch.

You can access the CLI by using the console port or, if an IP address has been assigned to the switch, by using Telnet. For details about using the console port, refer to the switch hardware installation guide.

Step 3 At the switch prompt, enter privileged EXEC mode:

```
Switch> enable
Switch#
```

Step 4 Enter the password of the *failed command switch.*

Step 5 Use the setup program to configure the switch IP information.

This program prompts you for IP address information and passwords. From privileged EXEC mode, enter **setup**, and press **Return**.

```
Switch# setup
         --- System Configuration Dialog ---
Continue with configuration dialog? [yes/no]: y

At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.

Basic management setup configures only enough connectivity
for management of the system, extended setup will ask you
to configure each interface on the system

Would you like to enter basic management setup? [yes/no]:
```

Step 6 Enter **Y** at the first prompt.

The prompts in the setup program vary depending on the switch you selected to be the command switch:

```
Continue with configuration dialog? [yes/no]: y
```

or

```
Configuring global parameters:
```

If this prompt does not appear, enter **enable**, and press **Return**. Enter **setup**, and press **Return** to start the setup program.

Step 7 Respond to the questions in the setup program.

When prompted for the host name, recall that on a command switch, the host name is limited to 28 characters. Do not use *-n*, where *n* is a number, as the last characters in a host name for any switch.

When prompted for the Telnet (virtual terminal) password, recall that it can be from 1 to 25 alphanumeric characters, is case sensitive, allows spaces, but ignores leading spaces.

Step 8 When prompted for the **enable secret** and **enable** passwords, enter the passwords of the *failed command switch* again.

Step 9 When prompted, make sure to enable the switch as the cluster command switch, and press **Return**.

Step 10 When prompted, assign a name to the cluster, and press **Return**.

The cluster name can be 1 to 31 alphanumeric characters, dashes, or underscores.

Step 11 When the initial configuration displays, verify that the addresses are correct.

Step 12 If the displayed information is correct, enter **Y**, and press **Return**.

If this information is not correct, enter **N**, press **Return**, and begin again at Step 9.

Step 13 Start your browser, and enter the IP address of the new command switch.

Step 14 From the Cluster menu, select **Add to Cluster** to display a list of candidate switches to add to the cluster.

Recovering from Lost Member Connectivity

Some configurations can prevent the command switch from maintaining contact with member switches. If you are unable to maintain management contact with a member, and the member switch is forwarding packets normally, check for these conflicts:

- A member switch (Catalyst 3550, Catalyst 3500 XL, Catalyst 2950, Catalyst 2955, Catalyst 2900 XL, Catalyst 2820, and Catalyst 1900 switch) cannot connect to the command switch through a port that is defined as a network port.
- Catalyst 3500 XL, Catalyst 2900 XL, Catalyst 2820, and Catalyst 1900 member switches must connect to the command switch through a port that belongs to the same management VLAN.
- A member switch (Catalyst 3550, Catalyst 2950, Catalyst 3500 XL, Catalyst 2900 XL, Catalyst 2820, and Catalyst 1900 switch) connected to the command switch through a secured port can lose connectivity if the port is disabled because of a security violation.

Preventing Autonegotiation Mismatches

The IEEE 802.3AB autonegotiation protocol manages the switch settings for speed (10 Mbps, 100 Mbps, and 1000 Mbps excluding GBIC ports) and duplex (half or full). There are situations when this protocol can incorrectly align these settings, reducing performance. A mismatch occurs under these circumstances:

- A manually-set speed or duplex parameter is different from the manually set speed or duplex parameter on the connected port.
- A port is set to autonegotiate, and the connected port is set to full duplex with no autonegotiation.

To maximize switch performance and ensure a link, follow one of these guidelines when changing the settings for duplex and speed:

- Let both ports autonegotiate both speed and duplex.
- Manually set the speed and duplex parameters for the ports on both ends of the connection.

Note If a remote device does not autonegotiate, configure the duplex settings on the two ports to match. The speed parameter can adjust itself even if the connected port does not autonegotiate.

GBIC Module Security and Identification

Cisco-approved Course Wave Division Multiplexer (CWDM) Gigabit Interface Converter (GBIC) modules have a serial EEPROM that contains the module serial number, the vendor name and ID, a unique security code, and cyclic redundancy check (CRC). When a CWDM GBIC module is inserted in the switch, the switch software reads the EEPROM to check the serial number, vendor name and vendor ID, and recompute the security code and CRC. If the serial number, the vendor name or vendor ID, the security code, or CRC is invalid, the switch places the interface in an error-disabled state.

Note If you are using a non-Cisco approved CWDM GBIC module, remove the GBIC or SFP module from the switch, and replace it with a Cisco-approved module.

After inserting a Cisco-approved GBIC module, use the **errdisable recovery cause gbic-invalid** global configuration command to verify the port status, and enter a time interval for recovering from the error-disabled state. After the elapsed interval, the switch brings the interface out of the error-disabled state and retries the operation. For more information about the **errdisable recovery** command, refer to the command reference for this release.

Diagnosing Connectivity Problems

This section describes how to troubleshoot connectivity problems:

- Using Ping, page 29-11
- Using Layer 2 Traceroute, page 29-12

Using Ping

This section consists of this information:

- Understanding Ping, page 29-11
- Executing Ping, page 29-11

Understanding Ping

The switch supports IP ping, which you can use to test connectivity to remote hosts. Ping sends an echo request packet to an address and waits for a reply. Ping returns one of these responses:

- Normal response—The normal response (*hostname* is alive) occurs in 1 to 10 seconds, depending on network traffic.
- Destination does not respond—If the host does not respond, a *no-answer* message is returned.
- Unknown host—If the host does not exist, an *unknown host* message is returned.
- Destination unreachable—If the default gateway cannot reach the specified network, a *destination-unreachable* message is returned.
- Network or host unreachable—If there is no entry in the route table for the host or network, a *network or host unreachable* message is returned.

Executing Ping

If you attempt to ping a host in a different IP subnetwork, you must define a static route to the network.

Beginning in privileged EXEC mode, use this command to ping another device on the network from the switch:

Command	Purpose
ping [ip] {*host* | *address***}**	Ping a remote host through IP or by supplying the host name or network address.

Note Though other protocol keywords are available with the **ping** command, they are not supported in this release.

This example shows how to ping an IP host:

```
Switch# ping 172.20.52.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echoes to 172.20.52.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Switch#
```

Table 29-1 describes the possible ping character output.

Table 29-1 Ping Output Display Characters

Character	Description
!	Each exclamation point means receipt of a reply.
.	Each period means the network server timed out while waiting for a reply.
U	A destination unreachable error PDU was received.
C	A congestion experienced packet was received.
I	User interrupted test.
?	Unknown packet type.
&	Packet lifetime exceeded.

To terminate a ping session, enter the escape sequence (**Ctrl-^ X** by default). You enter the default by simultaneously pressing and releasing the **Ctrl**, **Shift**, and **6** keys, and then pressing the **X** key.

Using Layer 2 Traceroute

This section describes this information:

- Understanding Layer 2 Traceroute, page 29-12
- Switches Supporting Layer 2 Traceroute, page 29-13
- Usage Guidelines, page 29-13
- Displaying the Physical Path, page 29-14

Understanding Layer 2 Traceroute

The Layer 2 traceroute feature allows the switch to identify the physical path that a packet takes from a source device to a destination device. Layer 2 traceroute supports only unicast source and destination MAC addresses. It determines the path by using the MAC address tables of the switches in the path. When the switch detects a device in the path that does not support Layer 2 traceroute, the switch continues to send Layer 2 trace queries and lets them time out.

The switch can only identify the path from the source device to the destination device. It cannot identify the path that a packet takes from source host to the source device or from the destination device to the destination host.

Switches Supporting Layer 2 Traceroute

The Layer 2 traceroute feature is available on these switches:

- Catalyst 2950 and Catalyst 2955 switches running Release 12.1(12c)EA1 or later
- Catalyst 3550 switches running Release 12.1(12c)EA1 or later
- Catalyst 4000 switches running Catalyst software Release 6.2 or later for the supervisor engine
- Catalyst 5000 switches running Catalyst software Release 6.1 or later for the supervisor engine
- Catalyst 6000 switches running Catalyst software Release 6.1 or later for the supervisor engine

Usage Guidelines

These are the Layer 2 traceroute usage guidelines:

- Cisco Discovery Protocol (CDP) must be enabled on all the devices in the network. For Layer 2 traceroute to functional properly, do not disable CDP.

  For a list of switches that support Layer 2 traceroute, see the "Switches Supporting Layer 2 Traceroute" section on page 29-13. If any devices in the physical path are transparent to CDP, the switch cannot identify the path through these devices.

Note For more information about enabling CDP, see Chapter 21, "Configuring CDP."

- A switch is reachable from another switch when you can test connectivity by using the **ping** privileged EXEC command. All switches in the physical path must be reachable from each other.
- The maximum number of hops identified in the path is ten.
- You can enter the **traceroute mac** or the **traceroute mac ip** privileged EXEC command on a switch that is not in the physical path from the source device to the destination device. All switches in the path must be reachable from this switch.
- The **traceroute mac** command output shows the Layer 2 path only when the specified source and destination MAC addresses belong to the same VLAN. If you specify source and destination MAC addresses that belong to different VLANs, the Layer 2 path is not identified, and an error message appears.
- If you specify a multicast source or destination MAC address, the path is not identified, and an error message appears.
- If the source or destination MAC address belongs to multiple VLANs, you must specify the VLAN to which both the source and destination MAC addresses belong. If the VLAN is not specified, the path is not identified, and an error message appears.

- The **traceroute mac ip** command output shows the Layer 2 path when the specified source and destination IP addresses belong to the same subnet. When you specify the IP addresses, the switch uses Address Resolution Protocol (ARP) to associate the IP addresses with the corresponding MAC addresses and the VLAN IDs.
  - If an ARP entry exists for the specified IP address, the switch uses the associated MAC address and identifies the physical path.
  - If an ARP entry does not exist, the switch sends an ARP query and tries to resolve the IP address. If the IP address is not resolved, the path is not identified, and an error message appears.
- When multiple devices are attached to one port through hubs (for example, multiple CDP neighbors are detected on a port), the Layer 2 traceroute feature is not supported. When more than one CDP neighbor is detected on a port, the Layer 2 path is not identified, and an error message appears.
- This feature is not supported in Token Ring VLANs.

Displaying the Physical Path

You can display physical path that a packet takes from a source device to a destination device by using one of these privileged EXEC commands:

- **tracetroute mac** [**interface** *interface-id*] {*source-mac-address*} [**interface** *interface-id*] {*destination-mac-address*} [**vlan** *vlan-id*] [**detail**]
- **tracetroute mac ip** {*source-ip-address* | *source-hostname*}{*destination-ip-address* | *destination-hostname*} [**detail**]

For more information, refer to the command reference for this release.

Using Debug Commands

This section explains how you use the **debug** commands to diagnose and resolve internetworking problems. It contains this information:

- Enabling Debugging on a Specific Feature, page 29-15
- Enabling All-System Diagnostics, page 29-15
- Redirecting Debug and Error Message Output, page 29-15
- Using the debug autoqos Command, page 29-16

Caution Because debugging output is assigned high priority in the CPU process, it can render the system unusable. For this reason, use **debug** commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff. It is best to use **debug** commands during periods of lower network traffic and fewer users. Debugging during these periods decreases the likelihood that increased **debug** command processing overhead will affect system use.

Note For complete syntax and usage information for specific **debug** commands, refer to the command reference for this release.

Enabling Debugging on a Specific Feature

All **debug** commands are entered in privileged EXEC mode, and most **debug** commands take no arguments. For example, beginning in privileged EXEC mode, enter this command to enable the debugging for EtherChannel:

```
Switch# debug etherchannel
```

The switch continues to generate output until you enter the **no** form of the command.

If you enable a **debug** command and no output appears, consider these possibilities:

- The switch might not be properly configured to generate the type of traffic you want to monitor. Use the **show running-config** command to check its configuration.
- Even if the switch is properly configured, it might not generate the type of traffic you want to monitor during the particular period that debugging is enabled. Depending on the feature you are debugging, you can use commands such as the TCP/IP **ping** command to generate network traffic.

To disable debugging of SPAN, enter this command in privileged EXEC mode:

```
Switch# no debug etherchannel
```

Alternately, in privileged EXEC mode, you can enter the **undebug** form of the command:

```
Switch# undebug etherchannel
```

To display the state of each debugging option, enter this command in privileged EXEC mode:

```
Switch# show debugging
```

Enabling All-System Diagnostics

Beginning in privileged EXEC mode, enter this command to enable all-system diagnostics:

```
Switch# debug all
```

Caution Because debugging output takes priority over other network traffic, and because the **debug all** privileged EXEC command generates more output than any other **debug** command, it can severely diminish switch performance or even render it unusable. In virtually all cases, it is best to use more specific **debug** commands.

The **no debug all** privileged EXEC command disables all diagnostic output. Using the **no debug all** command is a convenient way to ensure that you have not accidentally left any **debug** commands enabled.

Redirecting Debug and Error Message Output

By default, the network server sends the output from **debug** commands and system error messages to the console. If you use this default, you can use a virtual terminal connection to monitor debug output instead of connecting to the console port.

Possible destinations include the console, virtual terminals, internal buffer, and UNIX hosts running a syslog server. The syslog format is compatible with 4.3 Berkeley Standard Distribution (BSD) UNIX and its derivatives.

Note Be aware that the debugging destination you use affects system overhead. Logging messages to the console produces very high overhead, whereas logging messages to a virtual terminal produces less overhead. Logging messages to a syslog server produces even less, and logging to an internal buffer produces the least overhead of any method.

For more information about system message logging, see Chapter 24, "Configuring System Message Logging."

Using the debug autoqos Command

You can use the **debug autoqos** privileged EXEC command to display quality of service (QoS) commands that are automatically generated when automatic-QoS (auto-QoS) is enabled.

Beginning in privileged EXEC mode, follow these steps to display the QoS commands and enable auto-QoS for voice over IP (VoIP) within a QoS domain:

	Command	Purpose
Step 1	**debug autoqos**	Enable debugging for auto-QoS. When debugging is enabled, the switch displays the QoS commands that are automatically generated when auto-QoS is enabled or disabled.
Step 2	**configure terminal**	Enter global configuration mode.
Step 3	**interface** *interface-id*	Enter interface configuration mode, and specify the interface that is connected to a Cisco IP Phone. You also can specify the uplink interface that is connected to another switch or router in the interior of the network.
Step 4	**auto qos voip** {**cisco-phone** | **trust**}	Enable auto-QoS. The keywords have these meanings: • **cisco-phone**—If the interface is connected to a Cisco IP Phone, the QoS labels of incoming packets are trusted only when the IP phone is detected. • **trust—**The uplink interface is connected to a trusted switch or router, and the VoIP classification in the ingress packet is trusted.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show auto qos interface** *interface-id*	Verify your entries. This command displays the auto-QoS configuration that was initially applied; it does not display any user changes to the configuration that might be in effect.

For more information about auto-QoS, see the "Configuring Auto-QoS" section on page 27-9.

This example shows how to display the QoS commands that are automatically generated when auto-QoS is enabled:

```
Switch# debug autoqos
AutoQoS debugging is on
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
```

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# auto qos voip cisco-phone
```

Using the crashinfo File

This feature is available if your switch is running IOS Release 12.1(11)EA1 or later.

The crashinfo file saves information that helps Cisco technical support representatives to debug problems that caused the IOS image to fail (crash). The switch writes the crash information to the console at the time of the failure, and the file is created the next time you boot the IOS image after the failure (instead of while the system is failing).

The information in the file includes the IOS image name and version that failed, a dump of the processor registers, and a stack trace. You can give this information to the Cisco technical support representative by using the **show tech-support** privileged EXEC command.

All crashinfo files are kept in this directory on the Flash file system:

flash:/crashinfo/crashinfo_*n* where *n* is a sequence number.

Each new crashinfo file that is created uses a sequence number that is larger than any previously-existing sequence number, so the file with the largest sequence number describes the most recent failure. Version numbers are used instead of a timestamp because the switches do not include a real-time clock. You cannot change the name of the file that the system will use when it creates the file. However, after the file is created, you can use the **rename** privileged EXEC command to rename it, but the contents of the renamed file will not be displayed by the **show stacks** or the **show tech-support** privileged EXEC command. You can delete crashinfo files by using the **delete** privileged EXEC command.

You can display the most recent crashinfo file (that is, the file with the highest sequence number at the end of its filename) by entering the **show stacks** or the **show tech-support** privileged EXEC command. You also can access the file by using any command that can copy or display files, such as the **more** or the **copy** privileged EXEC command.

Supported MIBs

This appendix lists the supported management information base (MIBs) for this release. It contains these sections:

- MIB List, page A-1
- Using FTP to Access the MIB Files, page A-3

MIB List

Note The Catalyst 2955 switch supports the ENTITY-MIB, CISCO-ENVMON-MIB and CISCO-ENTITY-ALARM-MIB.

- BRIDGE-MIB (RFC1493)
- CISCO-2900-MIB
- CISCO-BULK-FILE-MIB
- CISCO-CDP-MIB
- CISCO-CLUSTER-MIB
- CISCO-CONFIG-MAN-MIB
- CISCO-ENTITY-ALARM-MIB (Catalyst 2955 only)
- CISCO-ENTITY-VENDORTYPE-OID-MIB
- CISCO-ENVMON-MIB
- CISCO-FLASH-MIB
- CISCO-FTP-CLIENT-MIB
- CISCO-IGMP-FILTER-MIB
- CISCO-IMAGE-MIB
- CISCO-MAC-NOTIFICATION-MIB
- CISCO-MEMORY-POOL-MIB
- CISCO-PAGP-MIB
- CISCO-PING-MIB
- CISCO-PORT-SECURITY-MIB

- CISCO-PROCESS-MIB
- CISCO-PRODUCTS-MIB
- CISCO-RTTMON-MIB (subsystems supported: sub_rtt_rmon and sub_rtt_rmonlib)
- CISCO-SMI
- CISCO-STACKMAKER-MIB
- CISCO-STP-EXTENSIONS-MIB
- CISCO-SYSLOG-MIB
- CISCO-TC
- CISCO-TCP-MIB
- CISCO-VLAN-MEMBERSHIP-MIB
- CISCO-VTP-MIB
- ENTITY-MIB
- IANAifType-MIB
- IF-MIB (RFC 1573)
- OLD-CISCO-CHASSIS-MIB
- OLD-CISCO-CPU-MIB
- OLD-CISCO-INTERFACES-MIB
- OLD-CISCO-IP-MIB
- OLD-CISCO-MEMORY-MIB
- OLD-CISCO-SYSTEM-MIB
- OLD-CISCO-TCP-MIB
- OLD-CISCO-TS-MIB
- RFC1213-MIB
- RFC1398-MIB
- RMON-MIB (RFC 1757)
- RS-232-MIB
- SNMPv2-MIB
- SNMPv2-SMI
- SNMPv2-TC
- TCP-MIB
- UDP-MIB

Using FTP to Access the MIB Files

You can obtain each MIB file by using this procedure:

Step 1 Use FTP to access the server **ftp.cisco.com**.

Step 2 Log in with the username **anonymous**.

Step 3 Enter your e-mail username when prompted for the password.

Step 4 At the `ftp>` prompt, change directories to **/pub/mibs/v1** and the **/pub/mibs/v2**.

Step 5 Use the **get** *MIB_filename* command to obtain a copy of the MIB file.

Note You can also access information about MIBs on the Cisco web site:
http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

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